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EDITORIAL

SOME ASPECTS OF FRUIT CULTIVATION IN CEYLON

THE high state of efficiency which fruit cultivation has now attained in such countries as Europe, America, Australia and South Africa can be attributed mainly to the energy and enterprise of their fruit nurserymen and fruit-growers' associations, assisted by horticultural research in the improvement and propagation of fruit trees. Ceylon has lacked any such organised service, and the growing of the better kinds of fruit has been left to a few individual pioneers and to the three Botanic Gardens of the Department.

The series of articles on Fruit Cultivation in Ceylon published in *The Tropical Agriculturist* during the past year has indicated that Ceylon possesses a range of varieties of fruit attained by few other tropical countries and that many of these can take their place as first rate marketable commodities, if due consideration is paid to the methods of propagation and cultivation which these demand and provided they are grown in localities to which they are best suited. In the past but little attention has been paid to propagation and adequate cultivation, and it has been only too often the case that fruit-growing in Ceylon has been carried out somewhat indiscriminately in localities to which certain varieties were not well suited, thus leading to disappointing results in respect of both the yield of crop and the quality of fruit. Throughout the above-mentioned series

of articles considerable emphasis has been laid on the propagation of fruit trees by vegetative means and in this number a short note is given on the various methods by which fruit trees can be propagated vegetatively.

Fruit propagation in Ceylon is still in its infancy, but a start has been made at Peradeniya with the object of improving some of the more important tropical fruits, such as grapefruit, orange, mango, avocado pear, etc. by vegetative means. Preliminary experiments are being carried out to ascertain the most suitable rootstocks for various fruits. These experiments have indicated that, under Ceylon conditions, the country mandarin is proving to be the best citrus stock tried so far in its resistance to citrus canker, while sour orange is a sound stock for most citrus. Soursop is a good stock for cherimoya, while the common wild mango is useful for the choicer varieties of mangoes. Mangosteen does well on various species of Garcinia, and Mexican and Indian varieties of avocado on the local varieties of this fruit.

As regards the fruits of minor importance, budding facilities are not available at present, but at Peradeniya, Hakgala and Heneratgoda, seedlings are being raised on a scale never before attempted and are for sale and free distribution to village growers. Apart from the assistance which is obtainable from the Staffs of the Botanic Gardens, an assistant with a special knowledge of pruning and budding and of the diseases of fruit trees is stationed at Bandarawela and his services are available in the hill regions to all requiring them. Similar arrangements for rendering assistance to fruit-growers in other centres are being planned.

Fruit trees, especially various kinds of citrus and mango, are subject to the attacks of insect pests and diseases, and spraying experiments are in progress at Peradeniya for the control of many of these troubles.

The formation of some sort of marketing organization should precede any attempt to encourage the further production by small growers of the better kinds of local fruit for home consumption and possibly to replace a portion of the fruit now imported from other countries. Meanwhile considerable progress has been made by the Department in improving the quality of some of our local fruit by vegetative methods of propagation.

RICE YIELDS

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FOR many years Ceylon has had the unenviable reputation of growing much less rice per acre than other rice producing countries. Reference is so frequently made to this fact without any explanation that the subject warrants more critical examination. The following table shows the yields of unhusked rice in the chief rice producing countries and in Ceylon. The figures for Ceylon have been taken from the Ceylon Blue Book for the period 1921-25 and are based on estimates by Revenue Officers. The estimated yields were admittedly open to serious error and after 1925 figures for yields were not included in the statistics. The figures for the other countries cover the period 1924-25 to 1928-29 and have been compiled from the International Review of Agriculture, Vol. XXII, 1st January 1931.

TABLE SHOWING YIELDS OF RICE (UNHUSKED)

Average 1924-25 to 1928-29

Country	Area in 1000 ac.	Production in 1000 bus. of 45 lb.	Yield per acre bushels
Spain	120	14,905	124
Italy	349	31,748	91
Japan	7,754	522,480	67
U.S.	952	39,110	41
Formosa	1,394	57,458	41
Korea	3,857	131,303	34
Java	7,343	234,266	32
Siam	3,599	127,425	35
India	77,691	2,328,533	30
Ceylon (1921-25)	792	11,088	14

The figures show that the average yield of rice in Ceylon is less than half the yield in India and less than one-eighth of the yield in Spain. While it is not expected that Ceylon yields should

compare favourably with those in Spain or Italy where manuring is heavy it would appear reasonable to expect that yields in Ceylon should be similar to those in the adjacent country of India. That they are not so may be ascribed to the following reasons:

(a) The larger proportion of the paddy area in Ceylon is cultivated with short-aged (three to four-month) varieties. It is estimated that less than 25 per cent. of the area is cultivated with six-month varieties. Other things being equal, yield is positively correlated with age. Climatic and irrigation conditions preclude little, if any, increase in the area under long-aged rices.

(b) The cropped area in Ceylon includes land that is cropped twice a year. In Ceylon the area of such land is appreciable; in India it is believed to be small. Once cropped land yields more *per crop* at least than land cropped twice a year. The effect of two croppings on average yields can be seen from the following example: In India one acre of six-month rice yields, say 30 bushels, i.e., 30 bushels per acre. In Ceylon an acre cropped twice may yield 25 bushels for *maha* (a four-month or, in some places, a six-month crop) and 20 for *yala* (a three-month crop); as the statistics show total sown areas the average yield is arrived at as follows: two acres yield 45 bushels, average per acre equals $22\frac{1}{2}$ bushels.

(c) It is believed that the area of paddy land which fails to mature a crop owing to scarcity of water is larger in Ceylon than in India.

(d) Transplanting is almost universal in India. It is the exception in Ceylon although the practice is increasing owing to the propaganda efforts of the Department of Agriculture. It is doubtful, however, to what extent transplanting is profitable with three-month varieties which occupy so large a share of the Ceylon acreage. Normally, transplanted rice yield more than broadcasted.

The Ceylon yields previously given in the Blue Book have been based on data which include areas of land sown but which, generally owing to failure of rain water, have not matured a crop. If these not inappreciable areas are excluded, Ceylon

yields are more favourable. Paddy grown under major irrigation works seldom suffers from insufficient water supply and the yield of 161,060 acres under these works in 1931 is given by the Director of Irrigation in his Report as 21·2 bushels per acre. In these figures the area is precise, but yields are based on estimates by Revenue Officers and not on crop cuttings. Estimates of yields which are made after consultation with cultivators are generally on the low side. Both landlords and tenants are reluctant to divulge true yields owing to fears of increased water rates or rentals. It may be taken, therefore, that the yield of rice under irrigation in Ceylon is certainly not less and probably a good deal more than 21·2 bushels per acre. For the three and four-month paddies generally grown under irrigation the yields compare not too unfavourably with those of irrigated areas in India.

While it has been shown that Ceylon rice yields are not quite so bad as the frequent and bare references would make out it must nevertheless be frankly admitted that in general yields are definitely too low for a country so highly developed in other directions as is Ceylon. Fortunately, means of increasing yields are ready to hand and include such comparatively simple methods as the use of pure line seed, more thorough preparation of the seed bed with the iron plough and Burmese harrow, weeding, transplanting (in certain areas), and manuring. The use of artificial fertilizers at this time of low prices cannot be advocated on any large scale, but the use of small quantities of green manure and cattle dung is within the reach of all.

But even without manuring the use of pure-line seed and the practice of good cultivation methods will produce excellent yields where the water supply is sufficient. The following precise figures show the yields which have been obtained by the writer from irrigated rice in the Eastern Province without manures but with good cultivation and seed:

(a) At Illupadichchenai with a four-month pure-line paddy in 1930-31, 1·77 acres yielded at the rate of 32 bushels per acre.

(b) At the same station in 1931-32 the same paddy on 5·31 acres yielded at the rate of 49 bushels per acre.

(c) At the same station in 1932-33 the same paddy on a larger area of 10 acres yielded 354 bushels or 35·4 bushels per acre and the yield would have been greater had it not been for abnormally heavy rains before harvest.

(d) At Sengapadi in 1931 a three-month mixed paddy yielded 102·78 bushels from 3·08 acres or 33 bushels per acre.

(e) In 1932 at the same station similiar aged pure-line paddies grown on 3·60 acres yielded at the rate of 38·5 bushels per acre.

(f) At Tamblegam, a fertile area in the Trincomalee District, pure-line three and three-and-a-half month paddies grown on 4·31 acres yielded at the rate of 47 bushels per acre in 1931 and 49·6 bushels in 1932.

Under experimental conditions at Peradeniya where six-month transplanted varieties are cultivated the writer has frequently obtained yields of over 60 bushels per acre. It is believed, however, that the less spectacular figures quoted above, being obtained from larger areas, over a number of years and in different districts, will carry greater conviction of the power of Ceylon rice fields to compete on equal terms with most of the other rice-growing countries. By the use of green manure, cattle dung or artificial fertilizer the above quoted satisfactory yields can easily be increased.

It is a calamity that at this time of possible great improvements in the method of rice cultivation the world price of rice should be so low. With paddy selling over large areas in Ceylon at under Re. 1·00 per bushel there is little incentive for a cultivator to practise better methods. It is believed by many that artificial methods of raising the price are now justifiable.

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME (CEYLON)

CEYLON CLONES. I

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FOREWORD

THIS article, which gives yield records and other information of Ceylon clones test-tapped in 1932, is the first of a series of annual reports which will increase in interest and importance in successive years. Until recently no clones raised from Ceylon mother-trees have been old enough for test-tapping, and estates have had to rely on importations from Malaya and the Dutch East Indies for the supply of proved high-yielding planting material. There can be no doubt that Ceylon possesses as good potential clones as any other country, and it is clear that the most reliable material for use in the Island will be that which has been tested and proved under the conditions in which it is to be grown. Special interest, therefore, is attached to the performance of Ceylon and foreign clones tested under Ceylon conditions. At the present time the number of Ceylon clones under test-tapping is small, and in no case are the budgrafts old enough for the records to be considered as more than preliminary indications of future potentialities. During the course of the next few years, however, a large number of clones on estates and at the Rubber Research Scheme Experiment Station will come into tapping, and it should soon be possible to recommend Ceylon material of proved high-yielding capacity.

Particulars are given in this report of clones established at the Rubber Research Scheme Experiment Station, Nivitigalakele, and on estates which are co-operating with the Research Scheme in this work. Such co-operation would appear to be mutually advantageous to the Research Scheme and to the estates concerned, and records of any budgrafts which may be in tapping on estates will be welcomed.

Acknowledgment is here made to the undermentioned proprietors who have kindly given permission for the publication of the records of clones established from mother-trees on their properties:

The Govinna Rubber Company, Limited.
The Lavant Rubber Company, Limited.
The Mirishena (Kalutara) Rubber Company, Limited.
Mr. C. E. A. Dias.

PRESENTATION OF RESULTS

In presenting the yield records and other information the following report is divided into sections according to where the clones are planted. Thus clones tapped at the Rubber Research Scheme Experiment Station are considered together, although the mother-trees are situated on various estates in different districts. Each clone is named according to the name and number of the estate mother-tree from which it is derived, and for convenience an official abbreviation is used.

The unit of measurement chosen for representing yield is grams of dry rubber per tapping. In practice the total weight of rubber obtained in the year is probably of greater interest to the planter, and when possible this figure will be given in subsequent years. In 1932, however, the number of tappings for all clones mentioned in this report was relatively small, and the figures for total yield of rubber in the year would have little significance.

Another yield unit introduced in this report is yield per foot of tapping cut. Although this measure is of no great interest with very young trees it will be of considerable value with older buddings as a means of comparing clones planted under different growth conditions or tapped on varying proportions of the circumference.

The yield data, together with measurements of girth and length of tapping cut, are given in Tables I-VI. Figures for thickness of primary and renewing bark are also shown in the same tables.

It is emphasised that the yielding capacity of a clone is by no means the only important criterion of its economic value. Rate and habit of growth, resistance or susceptibility to disease and wind damage, bark renewal, wound recovery, colour and quality of rubber, etc. are all important considerations in respect of which individual clones exhibit variation, and although it should eventually be possible to select clones which show to advantage in all respects, in the meantime it might be preferable to chose a moderate yielding clone which gives the minimum trouble in upkeep and attention. Notes on these points are accordingly being compiled for individual clones, and the information given in this report will be added to in future years.

CLONES AT RUBBER RESEARCH SCHEME EXPERIMENT STATION, NIVITIGALAKELE

GENERAL NOTES

The Experiment Station, Nivitigalakele, was opened in three clearings, in 1926, 1927 and 1928 respectively, with the primary object of testing clones established from high-yielding mother-trees on Ceylon estates. A full account of the development and work at the Station is given in Rubber Research Scheme *Quarterly Circular* Vol. 8, Parts 2 and 3, but a brief statement of the planting history and conditions of the 1926 clearing, the area in which the clones so far test-tapped are planted, will not be out of place.

Clearing, Planting, Budding.—This area, about 12 acres in extent, was cleared from jungle in 1926 and planted on contour platforms at approximately 106 trees per acre. Six acres were planted in July 1926, with stumps raised from seed of known mother-trees at Peradeniya and Heneratgoda, and the remainder was planted with basket plants, also from known mother-trees, in October-November, 1926. Budding in the field was commenced in May 1927, but owing to poor growth of the stocks and the difficulty of budding on to transplanted stumps the early results were disappointing. This, in conjunction with scarcity of budwood from suitable mother-trees, has resulted in slow and uneven development in the clearing with the consequence that only 19 budgrafts were large enough to be test-tapped in April 1932.

Distribution of Clones.—The original intention to allot 100 trees to each clone was followed out with 11 clones, the trees of each clone being scattered throughout the clearing so as to obtain all combinations of stock and scion. The clearing was completed with 6 further clones represented by a small number of trees each, a number of unbudded seedlings being left as a control.

Soil Manuring.—The area over which the trees test-tapped in 1932 are distributed is approximately six acres. The soil in this portion of the Station is a very poor "cabooky" sub-soil containing little or no humus. Great difficulty was at first experienced in establishing green manures and cover-crops, but there is now a fair cover in most parts. As mentioned above early growth of the rubber was slow, but applications of manure and other cultural operations have effected a marked improvement. The

area in which the tapped trees are situated was manured with calcium cyanamide in June 1928, and with general mixtures in September 1928, September 1929, and September 1931.

Tapping.—Test-tapping was commenced in October 1931, all trees being tapped with a girth of 16 ins. or more at a height of three ft. from the union.* The trees were tapped in October and December 1931, and were then rested until April 1932, when further trees were taken into tapping. Altogether 19 budgrafts representing six clones were tapped as from April 1932. The yield of only two clones, viz. Govinna 771 and Lavant 28 (abbreviated to G. 771 and LAV. 28) are given in this report, the yields from the other clones being too small to be of interest. The latter yields, however, will be given in subsequent reports should later records show promise.

Tapping of the budgrafts was carried out on alternate days on a half-spiral, the cut being opened at an angle of 25° at a height of 48 ins. from the union. Bark consumption was at the rate of about 6 ins. per annum. As will be seen in Tables I and II the number of tappings during the period April-December 1932, was only 86, this relatively small number being accounted for by the interference to tapping caused by the exceptionally wet weather in the latter half of the year. Only full tappings have been included in the records though on some days the trees were tapped late in the morning.

Recording.—The method of recording yields at the Station is as follows:

The latex from each tree is coagulated in the cup by the tapper, and the coagulum is squeezed out as thin as possible and hung on a sheltered wire support near the tree. At the end of each month the samples are transferred to a wire bearing the number of the tree and, after drying in a smokehouse, are brought to the laboratories to be weighed. Each day's biscuit contains the scrap from the previous tapping. In order to determine the dry rubber content periodic measurements of the latex were made, but on account of the small yields from each individual tree the figures for 1932 were not altogether satisfactory and are not given in this report. Accurate determinations will be made for promising clones in future years.

The yields for 1932 of the individual trees of clones G. 771 and LAV. 28 are given in Tables I and II, the monthly and annual averages being expressed in grams of dry rubber per

tapping. Figures for girth and length of tapping cut are also given and the yield per foot of cut has been calculated. The tables also include measurements of the thickness of primary and renewing bark.

NOTES ON INDIVIDUAL CLONES

Clone G. 771.—Reference to table I will show that the average yield per tapping for the seven trees for the period April-December 1932, was 13·1 grams, the average age being about five years from the time of budding. This figure compares favourably with the early yields of the proved A.V.R.O.S. clones on the basis of either age or circumference, and it is satisfactory to note a steady increase in yield throughout the year. It is impossible to predict the future potentialities of a clone as the result of one year's tapping at this tender age, but we may say that Clone G. 771 shows distinct promise.

Habit and rate of growth are satisfactory. The trees have an upright branching system, i.e. the branches tend to grow vertically rather than to spread horizontally. This seems to be an advantage as enabling a greater density of planting.

Primary bark is rather thin but renewal is very good. The figures given in table I show that after ten months the average thickness of renewing bark is 87 per cent. of that of the primary bark.

One case of pink disease has occurred out of the total number of 105 trees in the clone, but no other trouble with disease or wind damage is to be reported.

The only defects which have so far developed concern the behaviour of the latex; this continues to flow from the trees until late in the morning, and at the same time there is a marked tendency to early clotting. It remains to be seen whether these defects persist when the trees are mature and are sufficiently troublesome to offset other good qualities.

Clone LAV. 28.—The average yield for the four trees in tapping was 8·6 grams (see Table II). This figure is rather lower than the yield of most of the proved foreign clones at a corresponding age or size, but a satisfactory increase throughout the year is to be noted.

The trees of this clone show strong growth, the crown being large with a spreading branching system. Primary bark is of a good thickness and renewal is excellent. Four cases of pink disease have occurred.

TABLE I

Clone Govinna 771

Tree No.	Date of budding	Girth at 3 ft. on 1-10-32		Average yield in grams dry rubber per tapping — 1932									Average per tapping for year	Length of tapping cut on 1-10-32	Average yield per ft. of tapping cut	Thickness of bark	
				April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.				Primary at 3 ft. on 14-2-33	Renewing, 10 months' renewal
				Number of tappings									Total				
		ins.	cms.	8	9	10	12	9	9	5	10	14	86	ins.	grams	mms.	mms.
38	9-8-27	17·75	45·1	6·4	5·9	7·6	10·5	11·4	13·6	17·7	19·1	16·8	12·2	10·0	14·6	6·0	5·0
91	9-8-27	19·0	48·3	5·4	6·7	9·7	9·9	9·1	14·6	13·9	20·8	16·9	12·2	10·75	13·6	5·5	5·0
98	9-8-27	19·75	50·2	7·4	6·7	7·3	11·1	11·1	21·0	21·7	24·9	20·5	14·6	11·25	15·6	5·5	4·5
199	9-8-27	19·5	49·5	9·5	9·0	9·6	12·1	13·0	22·0	25·5	26·5	22·3	16·5	11·25	17·6	5·0	4·5
386	26-5-27	20·5	52·1	5·4	5·2	5·7	8·0	8·9	16·1	14·6	18·8	13·0	10·6	11·5	11·1	6·0	4·0
403	25-7-28	20·0	50·8	4·3	4·9	6·5	10·1	8·1	16·0	22·0	29·5	19·2	13·4	10·75	14·9	4·5	5·5
558	10-8-27	18·0	45·7	8·9	8·0	7·9	9·6	11·2	12·5	16·2	20·9	13·7	12·0	9·75	14·8	5·5	4·5
Average for clone		19·2	48·8	6·8	6·6	7·8	10·2	10·4	16·5	18·8	22·9	17·5	13·1	10·75	14·6	5·4	4·7

TABLE II

Clone Lavant 28

Tree No.	Date of budding	Girth at 3 ft. on 1-10-32		Average yield in grams dry rubber per tapping. 1932									Average per tapping for year	Length of tapping cut on 1-10-32	Average yield per ft. of tapping cut	Thickness of bark	
				April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.				Primary at 3 ft. on 14-2-33	Renewing, 10 months' renewal
				Number of tappings									Total				
		ins.	cms.	8	9	10	12	9	9	5	10	14	86	ins.	grams	mms.	mms.
131	9-11-27	25·75	65·4	7·0	7·1	7·5	8·2	8·1	12·3	17·0	24·7	19·6	12·6	13·5	11·2	8·0	5·5
260	10-11-27	19·5	49·5	2·5	3·1	4·3	5·1	4·7	6·3	9·3	16·5	10·7	7·1	11·0	7·7	7·0	6·0
339	10-11-27	21·75	55·2	4·1	2·9	3·0	4·2	4·3	4·5	5·6	9·7	14·5	6·4	10·25	7·5	6·0	6·5
443	2-8-28	19·25	48·9	5·8	7·1	7·8	7·0	5·5	5·7	8·3	8·6	14·7	8·2	10·0	9·8	6·0	4·0
Average for clone		21·6	54·8	4·8	5·0	5·6	6·1	5·6	7·2	10·0	14·9	14·9	8·6	11·2	9·0	6·75	5·5

HILLCROFT CLONES

GENERAL NOTES

A number of clones from high-yielding mother-trees on Hillcroft Estate were established on Stenness Estate in the Kalutara district in 1926, budding being carried out in the field in September of that year. Tapping of some of these clones was commenced in 1931, and we are much indebted to Mr. L. P. Gapp who from the commencement of test-tapping has co-operated fully with the Research Scheme in keeping the records. Particulars of two clones, Hillcroft 28 and 34 (HC. 28 and 34), are given in this report.

Stenness Estate was cleared from jungle in 1925 and consists at present of an irregularly mixed planting of seedlings and buddings of unproved clones, the stand being approximately 90 trees per acre. The land is undulating, the ground having at the present time a moderate cover of leguminous species and weeds. The areas containing the trees in tapping were manured in 1926, 1928, 1930 and 1931.

The trees in tapping of Clone HC. 28 are distributed over an area of about two acres, while those of HC. 34 are contained in one acre.

Tapping.—Tapping of Clones HC. 28 and 34 was commenced in August 1931. The trees were tapped in August-September and December 1931, and were then rested until April 1932. As at the Rubber Research Scheme Experiment Station tapping was on a half-spiral cut, commencing at a height of 48 ins. from the union measured from the top of the cut, the angle of slope being 25°. The rate of bark consumption during 1932 is somewhat difficult to calculate owing to the irregular tapping intervals, but it approximates to 9 ins. per annum calculated on a normal number of tappings.

Tapping was carried out on alternate days, but the trees were only tapped during good weather. As a consequence of the heavy rainfall during the latter half of 1932 the number of recorded tappings during the period April-December is only 55 and 54 for Clones 28 and 34 respectively, and the tapping system is actually equivalent to alternate day in alternate months. The trees were not tapped at all in June and in most other months there were intervals of 10-20 days in which the trees were rested.

Account must be taken of this mild system when considering the figures for average yield per tapping. The trees were tapped on a few additional occasions when "washouts" occurred, but only full tappings have been included in the records.

Recording.—The latex from each tree is brought in the cup to a shed, and, after being measured in cubic centimetres, is coagulated in the cup, the latter being marked with the number of the tree. The separate biscuits are strung on a wire for each tree, and at the end of the month are sent to the Rubber Research Scheme Laboratories to be weighed. The separate pieces of rubber are creped together for each tree, and this weight divided by the number of tappings gives the average yield per tapping for the month. Scrap rubber is not included. The daily measurements of latex are also received and the average dry rubber content calculated therefrom.

From the foregoing it can be seen that the recording of the yields from the Hillcroft clones is under the close supervision of the Rubber Research Scheme.

Quality of Rubber.—A preliminary investigation of the quality of the rubber from Clones HC. 28 and 34 has been carried out by the London Staff of the Scheme, and their report indicates that the inner properties are satisfactory in view of the age of the trees. Further tests will be carried out when the trees are older.

NOTES ON INDIVIDUAL CLONES

Clone HC. 28.—The monthly averages of the individual trees for 1931 and 1932 are given in Table III. It will be noted that the average for the clone for the period April-December 1932, reached the high figure of 41·9 grams (nearly $1\frac{1}{2}$ oz.), which represents a remarkable increase as compared with the first tappings.

In considering the figure for average yield per tapping the small number of recorded tappings must, however, be borne in mind. Had tapping been carried out on commercial lines the total yield for the year would have been much larger, but the average per tapping would in all probability have been rather smaller. 1932 was an exceptionally wet year, and it is hoped that in 1933 rain will not interefere with tapping to the same extent. There is no doubt that the clone is of outstanding

promise, and should a further year's records with a full number of tappings show a normal yield increase, the clone will have established itself as of economic value.

The growth of this clone is good, but the trees on Stenness Estate have inherited and accentuated a spiral fluting of the mother-tree. The twisting of the trees is very marked, but tapping will not be interfered with unless this feature becomes more pronounced as the trees mature. It seems probable that the phenomenon is related to the fact that the buds were taken from unpollarded wood, for on other estates where pollarded wood was used in establishing this clone the plants are growing quite straight.

The clone has not developed any other defects. Primary and renewing bark are satisfactory, and with the exception of bark rot on the tapping panels during wet weather in September 1931, no diseases have been reported. The average dry rubber content for 1932 was 37·1 per cent.

Clone HC. 34.—Reference to Table IV shows that the average yield per tapping for this clone in 1932 was 31·4 grams. The yield, though lower than that of HC. 28, is yet very high for the age of the trees, and it will be seen that if the length of tapping cut is taken into consideration the yield per foot of cut is nearly as great as for HC. 28. Despite this promising yield, however, the clone posseses defects which render its future economic value doubtful.

In the first place growth is very poor, the average girth at a height of three feet being only 48·1 cms. as compared with 60·5 cms. for HC. 28, the two clones being of the same age. The fact that trees are small is of itself no disadvantage as it would allow of a larger number of trees to be planttd per acre, but slow growth of young buddings is usually attended by an increase in the amount of care and attention necessary in early years. There is a marked tendency for the bark to split, leaving vertical wounds in which the wood is exposed, and the trees seem to be rather susceptible to bark rot. The rubber, also, is dark in colour and difficulty might be experienced in crepe manufacture.

In other respects the clone is satisfactory, and it remains to be seen whether its defects are sufficiently important to offset the high-yielding capacity.

MILLENIYA AND WAWULUGALA CLONES

GENERAL NOTES

In this section are included clones derived from mother-trees on Milleniya and Wawulugala Estates. Particulars are given below of four clones established and tapped in clearings on both the above estates, and it is convenient to consider the clones from both estates together. Many other clones are being tapped but at present the yields do not appear sufficiently promising for publication. We are indebted to Mr. C. E. A. Dias, the proprietor of the estate, for giving us access to his yield records.

The clearing on Milleniya consists of 27 acres of gently undulating land opened from small jungle in 1924. Seed was planted in 1924, but there was a high percentage of casualties, the vacancies being supplied with stumps in 1925. The clones mentioned in this report were budded in 1927. The soil is gravelly, probably average for the district, and has been improved by a thick cover of leguminous species, mostly *Pueraria phaseoloides*. Growth of the budgrafts has been uniformly good.

On Wawulugala Estate an area of about three acres of cinnamon and coconut land was cleared and planted with stumps in 1926, budding being done in 1927. The clearing is low-lying deniya land with a sandy soil, but growth has up to the present been very satisfactory.

Tapping.—Tapping was commenced in both clearings in 1930, but the trees were then so young that the records are not considered of sufficient interest for inclusion in this report. In 1931 tapping was carried out in the months October-December, the system being one half-spiral cut on alternate days. In 1932 the trees were rested until October (on Milleniya Estate until November) when tapping was resumed on two half-spiral cuts on opposite sides every three days. The heights of the two cuts were 40 ins. and 18 ins. respectively, measured from the top of the cut to the union. Bark consumption is at the rate of about $\frac{1}{2}$ inch per month on each cut; a figure for annual consumption cannot be given at present since it is intended to combine the tapping system with a periodic interval of rest.

The influence of this "double-cut" system on yield is discussed below.

Recording.—The latex from each tree is coagulated in the cup and each day's "biscuit", containing the scrap from the previous tapping, is hung on a wire near the tree. At the end of the month the biscuits from all trees of the same clone are rolled together, and the resultant sheet dried and weighed. Thus yields from individual trees have not hitherto been kept. Up to the present the yield recording has not been supervised by the Research Scheme, but in future the rubber is to be sent monthly to the laboratories to be weighed.

Table V shows the number of trees under test to be ten for each clone in the two clearings. The total number of trees tapped, however, is considerably larger, and the yields for 1931 were actually obtained from a varying number of trees in the different clones.

Yields.—The comparison of these yields under the "double-three" system of tapping with those of other Ceylon and foreign clones tapped on a single cut is somewhat difficult and uncertain. No information regarding the reaction of young budgrafts to this tapping system is available, but with mature seedlings it has been found that the average yield per tapping on two half-spiral cuts every three days (combined with alternate periods of six months' tapping and rest) is about 2·4 times as great as the yield on a single cut on alternate days. It is possible that this figure may need modification when applied to young budgrafts in general, and a differential response with different clones is certainly to be expected. Bearing in mind, however, that the trees in question received the benefit of nine to ten months' rest prior to opening the cuts in 1932, it seems probable that to effect a comparison with yields obtained on a single cut the figures shown in Table V should be divided by at least two. The figures for yield per foot of cut are here useful, but even so the fact that the tapping interval is three instead of two days must be taken into consideration.

On the basis of the above considerations the yields for 1932 are comparable with those of the best A.V.R.O.S. clones at a similar age. It would be unwise at this stage to place much reliance on the comparison of individual clones, but so far as can be judged at present Clones M.191, W.259 and W.320 appear to show the most promise.

NOTES ON INDIVIDUAL CLONES

Clone M.191.—With an average of 39·2 grams per tapping for the period October-December 1932, this is the highest yielding clone tapped on Wawulugala. The trees, however, are exceptionally big for their age and the yield per foot of tapping cut is not so high as for some other clones.

Growth of this clone is exceptionally rapid, and both primary and renewing bark are satisfactory.

Clone W.120.—The trees of this clone are very uniform in growth and have an extremely straight stem. The yield, however, is not very promising.

Clone W.259.—The average yield for the trees on both estates for the tapping period in 1932 was 34·1 grams per tapping.

Growth is very good, the trees having a straight stem with a moderate crown. Some of the trees are reported to drip late into the morning.

Clone W.320.—As the girth measurements indicate the trees of this clone are smaller than any of the other clones, and on account of the shorter tapping cuts the yield per foot is correspondingly high. Despite the slow growth it is reported that no trouble with the young buddings was experienced, and it is possible that the small size of the trees may be an advantage in enabling a greater density of planting. This would also be helped by the upright branching habit.

One case of damage due to wind has been noted, and bark rot occurred on a few trees in November 1931.

TABLE V

Milleniya and Wawulugala Clones

Clone	Where planted	No. of trees	When budded	Average girth at 40 ins.				Average yield per tapping in grams dry rubber and number of tappings for periods										Average length of tapping cuts in Feb. 1933	Average yield per ft. of cut for 1932	Thickness of Bark	
				Jan. 1932		Feb. 1933		1931		1932										Primary at 3 ft. on 22-3-33	Renewing, 17 months' renewal
								Oct.-Dec.		October		November		December		Oct.-Dec. 1932.					
				ins.	cms.	ins.	cms.	Yld	Tpgs	Yld	Tpgs	Yld	Tpgs	Yld	Tpgs	Yld	Tpgs	ins.	grams.	mms.	mms.
M. 191	M	10	Sep.-Dec. 1927.			23·1	58·7	6·0				not tapped						22·6		7·1	6·0
	W	10	Aug.-Oct. 1927.	20·0	50·8	27·3	69·3	12·8	35	30·7	5	44·5	8	38·2	9	39·2	22	28·1	16·7	6·8	6·0
W. 120	M	10	Sep.-Dec. 1927.			21·6	54·9	5·3				26·4	9	19·4	10	22·7	19	21·4	12·7	7·2	5·6
	W	10	August 1927.	16·6	42·2	22·5	57·1	8·6	35	15·0	5	26·8	8	28·3	9	24·7	22	23·2	12·8	6·1	4·6
W. 259	M	10	Sep.-Dec. 1927.			22·9	58·2	8·7				40·5	9	29·5	10	34·7	19	21·2	19·6	7·4	6·2
	W	10	May-Sep. 1927.	16·6	42·2	24·1	61·2	11·3	35	20·9	5	36·5	8	37·9	9	33·5	22	23·1	17·4	7·0	5·2
W. 320	M	10	Sep.-Dec. 1927.			21·0	53·3	9·2				32·9	9	36·6	10	34·8	19	20·4	20·5	6·8	5·2
	W	10	Aug.-Sep. 1927.	15·5	39·4	20·5	52·1	13·9	35	28·5	5	37·7	8	33·0	9	33·7	22	21·1	19·2	6·2	5·1

Tapping Systems 1931 Half-spiral alternate day.
1932 Two half-spirals opposite sides every 3 days.

M = Milleniya.
W = Wawulugala.

CLONE HENERATGODA 2

The justification for publishing yield records of this clone must be sought in the fame of the mother-tree and the wide interest taken in its progeny. Records of one tree tapped at Nivitigalakele and of ten trees tapped on Milleniya Estate are given in Table VI, but the yields obtained to date are not encouraging. It is to be noted that the trees on Milleniya Estate are tapped on two half-spiral cuts every three days.

TABLE VI

Clone Heneratgoda 2

Clone	Where planted	No. of trees	When budded	Girth at 40 ins. in February 1933		Tapping system	Average yield in grams dry rubber per tapping									Average per tapping for year	Length of tapping cut	Average yield per ft. of cut
							1932											
							April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.			
							Number of tappings									Total		
				ins.	cms.		8	9	10	12	9	9	5	10 9	14 10	86 19	ins.	grams
H. 2	Niviti-galakele.	1	Aug. 1927	19·0	48·3	½ spiral alt. day	2·2	1·9	3·0	3·8	4·6	3·3	4·1	8·3	10·1	5·0	9·5	6·3
H.2	Milleniya	10	July-Sept. 1926	22·9	58·2	two ½ spirals every 3 days.	Not tapped							22·6	25·5	24·1	22·5	12·9

A NOTE ON SUN-SCORCH OF BUDGRAFTS

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FOREWORD

IN a previous report [1] a brief description was given of damage due to sun-scorch of the callus bark near the union of young budgrafts, this form of injury having occurred on several estates during the exceptional drought experienced in January and February 1932. During the hot weather of March 1933, similar symptoms were observed on a number of budgrafts two to four years of age at the Experiment Station, Nivitigalakele. In most cases a cavity due to the decay of the stock snag had been filled some months earlier with a plastic mixture of Colas and sand, and it appeared that this filling, which absorbs a considerable amount of heat when exposed to a hot sun, had contributed to and accentuated the damage. The use of this Colas-sand filling has been tentatively advocated in previous reports [1] [2] and the purpose of this note, therefore, is to describe this manifestation of sun or heat-scorch and to qualify the recommendation.

SYMPTOMS AND OCCURRENCE

The injury starts as an irregular cracking of the raised bark growing over the cut end of the stock, the cracks developing approximately at right angles to one another. In mild cases only the outer bark is affected and no damage results. More generally, however, the bark dies back to the wood and there is a more or less complete ring of dead discoloured bark around the stock snag. At this stage there is the danger of parasitic fungi gaining entrance, and in several instances *Botryodiplodia Theobromae* has extended the damage several inches up the scion, and into the wood. In the cases examined there was no question of the fungus having gained entrance via the dead stock since the typical bluish-grey discolouration of the wood was isolated from the union by healthy tissue. The majority of affected trees at the Experiment Station, however, have not become invaded by Diplodia and show signs of rapid recovery by renewed callus growth.

Sun-cracking of this nature has only been observed in Ceylon where the raised portion, often described as the "elephant foot", is exposed to the direct rays of the hot mid-day and afternoon sun. No plants which were budded on the south-westerly side of the stock, and whose callus bark on the opposite side is therefore partly shaded at the time of day when the sun is hottest, have been found affected. This suggests that the trouble could be obviated by placing the bud on the south or west side of the stock, and this matter is further discussed below. Under normal conditions sun-scorch is only likely to occur when large stocks are budded since in such cases a delay in covering the stock snag is inevitable, and a relatively large area of callus bark is exposed in a plane nearly at right angles to the direct rays of the sun.

In the majority of cases on the Station a cavity due to the decay of the stock snag had previously been filled with a mixture of Colas and sand in the proportion 1: 2. This is a plastic filling which is gradually extruded by the in-growing callus so that unless it is removed, or until it falls off, the excess lies on the callus bark. The mixture appears to absorb sufficient heat when exposed to the sun to accentuate the scorching. Without a controlled experiment it is impossible to be sure to what extent the Colas-sand mixture has contributed to the damage, but it appears significant that the majority of severe cases are associated with this filling.

TREATMENT

The treatment of affected trees calls for little comment, and only where the damage has been extended by the invasion of Diplodia is any treatment considered necessary. In such cases all diseased bark should be removed and discoloured wood excised with a chisel. The exposed wood surface, which should be of a healthy colour, is then painted with a 20 per cent. mixture in water or Brunolinum Plantarium (or disinfectant of similar strength), and covered with a waterproof mixture such as Skene's pruning mixture.

PREVENTION

The obvious means of avoiding sun-scorch is either to orientate the bud so that the callus bark is partly shaded by the stem during the time of day at which the sun is hottest, or to provide an artificial or living shade. The first alternative is subject to the possible objection that it would be necessary to

bud on to the south or west side of the stock whereas it is considered preferable on general grounds to place the bud on the shady side of the stock. Provided the bud and young shoot are well shaded, however, there would appear to be little objection to budding on the sunny side.

The provision of a living shade, consisting of a few plants of an erect green manure planted close to the budgraft on the south side, is the best means of preventing sun-scorch. By sowing seed of a quick growing species a few months before hot weather is anticipated a good shade can be provided until the union of stock and scion has been completed. Where large stocks have been budded this measure can be recommended whether or not the Colas-sand filling has been used, since callus growth is in any event favoured by moist, shady conditions. The provision of shade is clearly of considerable importance in districts where a long period of hot dry weather is annually experienced.

Filling mixtures are now being used experimentally in which the sand is replaced by (1) saw dust and (2) coir dust, and it appears that these mixtures absorb less heat. It will probably be desirable, however, to inspect all treated trees prior to anticipated hot weather and remove any excess filling which has been extruded so as to lie on the callus bark.

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THE USE OF RECLAIM IN RUBBER MANUFACTURE*

A CRITICAL EXAMINATION

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THE interest of the rubber grower in the use of reclaimed rubber is based on the assumption that it is a substitute for crepe or sheet. This assumption may not be wholly correct as reclaim is sometimes used for purposes for which raw rubber is stated to be unsuitable, but there is little doubt that in many cases its use reduces the consumption of the plantation product. At present the consumption of reclaim in the U.S.A. is approximately 20 per cent. of that of raw rubber. Owing to its origin, reclaim may contain considerable quantities of compounding ingredients, so that if the whole of the reclaim now employed in industry were replaced by the same amount of raw rubber and compounding ingredients the increased consumption of raw rubber would be less than 20 per cent. and might amount to 10 per cent.

A variety of reasons for using reclaim has been recorded at different times. A few years ago the most important factor in favour of reclaim was its price relative to that of raw rubber. The proportion consumed in the U.S.A. was then more than double what it is at present. Some manufacturers in order to justify the use of such large percentages of reclaim carried out experiments to show that articles made with reclaim were equal in quality to those made with first grade crepe and sheet as long as the amount used was maintained within certain limits and the necessary allowance made for the compounding ingredients which reclaim already contained. This statement did not obtain universal approval amongst manufacturers and subsequent investigations support the view that reclaim has an adverse effect on the quality of the finished article. The considerable reduction in the proportion of reclaim now employed indicates

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that the views which some manufacturers held when the price of rubber was high is not the general opinion now that rubber is cheap.

The reason for the continued use of a proportion of reclaim now that the price advantage has largely disappeared may be connected with technical advantages, although of course there are other factors affecting the demand for reclaim. Some grades are cheaper than raw rubber: some manufacturers make their own reclaim and would prefer to keep their plant fully occupied. Moreover, it is not yet clear that the amount of reclaim employed has reached its lowest level. Manufacturers cannot change their mixings without carrying out extensive trials and tests to determine the effect of the change, and they are not likely to initiate these unless there is a prospect of stability in the relative prices of plantation rubber and reclaim. The proportion of reclaim used in the rubber industry only reacts slowly to reductions in the price of raw rubber, and it is not yet clear whether the technical advantages of reclaim are of sufficient value to ensure its continued use in the proportions now employed or whether there is likely to be still further reductions in sympathy with the relative prices of reclaim and raw rubber.

If reclaim possesses technical advantages over raw rubber it is important for the rubber grower to know exactly what they are in order to appreciatate the respects in which raw rubber is unsuitable and how it may be improved. The recent statements concerning the advantages of reclaim mostly refer to the effect of reclaim on the manipulation of rubber. The conversion of crepe and sheet into vulcanised articles necessitates heavy and expensive machinery and it is argued on behalf of reclaim that the amount of manipulation required by mixtures of rubber and reclaim is less than that required by rubber alone, so that although reclaim is in some cases more expensive than raw rubber it is more economical to use mixtures of rubber and reclaim than rubber alone.

None of the recently suggested beneficial effects of reclaim refers to the quality of the finished product. It is now generally admitted that where the maximum tensile strength or resistance to abrasion is required rubber alone is definitely superior to mixtures of rubber and reclaim; but it is claimed that there is a large range of purposes for which the excellent mechanical properties of rubber are not wholly essential and that in these cases

the processing economies effected by reclaim are of sufficient importance to justify its use even when the price of reclaim is higher than that of raw rubber.

British manufacturers who were consulted as to the reason for using reclaim irrespective of price were not very definite as to the technical value of reclaim except for special purposes which do not account for the quantity of reclaim still used in America. They made several suggestions however, and these combined with a study of those technical journals which publish regular notices on behalf of the reclaim industry indicate that there is a possibility of a mixture of reclaim and raw rubber having the following advantages over raw rubber alone:

(1) Less mastication required.

(2) Calendering and extrusion operations carried out more smoothly.

(3) Less alteration in shape after calendering and extruding.

(4) Improved moulding.

(5) Spreading doughs require less solvent.

The details of the advantages of reclaim have been placed on record so often that there appears to be a tendency to accept them as well-established facts, but a search of the literature indicates that there is little published scientific evidence. A study of the properties of reclaim was therefore made by the staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya) in order that quantitative data might be available. As the investigations proceeded it became evident that the advantages of using reclaim are not as definite as the constantly reiterated statements of the reclaim industry would lead one to suppose and in many cases the reclaim instead of being an aid to manipulation is a hindrance.

It is not proposed in this article to give details of the results obtained, as they have already been included in a paper on the effect of reclaim on the manipulation of rubber read before the London Section of the Institution of the Rubber Industry, March 13th, 1933. Altogether 22 samples of different grades of reclaim from six manufacturers were analysed and submitted to a series of tests by masticating with an equal weight of smoked sheet, mixing with various compounding ingredients and subjecting at

each stage to tests connected with manipulation. It was concluded that whereas there are only a few commercial grades of raw rubber, there are many grades of reclaim differing from each other in important respects. The samples examined might almost be regarded as constituting 22 different grades. No information was obtained as regards the uniformity of any of the grades, but reclaim is made from an assortment of scrap material which must inevitably change with the development of manufacturing practice, and so cause some variation in the nature of the finished reclaim.

The mixtures of rubber and reclaim sometimes required a much longer period of mastication to reach a fixed plasticity than rubber alone, and the better the quality of the reclaim the greater the adverse effect on mastication. The most beneficial effect was produced by the cheapest grade of reclaim, which reduced the period of mastication by about 20 per cent. when mixed with an equal weight of smoked sheet. Smaller proportions of reclaim had a similar effect, but in less degree. The cost of mastication is stated to be from $\frac{1}{4}$d. to $\frac{1}{2}$d. per lb. of rubber, so that the maximum economy in mastication effected by using a large proportion of any grade of reclaim does not exceed $\frac{1}{10}$d. per lb. of rubber and in the majority of cases there is an increase and not a decrease in mastication costs when raw rubber is replaced by reclaim.

After mastication in order to render the rubber soft and plastic, it is customary in manufacturing practice to mix in compounding ingredients as required. Owing to its origin, reclaim already contains considerable quantities of compounding ingredients, so that it is obvious that if rubber is replaced by reclaim the cost of incorporating the compounding ingredients already present in reclaim is saved. The use of reclaim, however, does not altogether eliminate the need for mixing. It is necessary, for example, to incorporate sulphur before it can be vulcanised, and it would be necessary to use large proportions of low-grade reclaim in order to effect an appreciable economy in the amount of milling required to incorporate the compounding ingredients for most mixings. It is not possible to do this without sacrificing the quality of the finished product. Mixing economies due to the use of reclaim are therefore limited to low-grade articles, in which high tensile strength and resistance to abrasion are not required.

After the incorporation of the compounding ingredients it is generally necessary to mould the rubber to the required shape either by passing through heated rolls known as a calender, or by forcing through a shaped die (extrusion). An argument for using small proportions of reclaim in high-grade rubber articles is that it enables calendering and extruding operations to be carried out more smoothly, and improves the moulding properties of the rubber. The experiments carried out in London failed to confirm the general truth of this argument. It was found that the most expensive grades of reclaim reduced the rate of extrusion of rubber mixings and only the cheapest grades effected an improvement. In addition the mixings without reclaim extruded more smoothly than those containing reclaim. Similarly other experiments in which the shape of the mixing was altered by direct pressure shewed that mixings containing reclaim were frequently more difficult to deform than those without. An interesting result of these experiments was the discovery that reclaim mixings required high loads to obtain the best deformation results relative to the corresponding mixings without reclaim. In other words, reclaim mixtures which were difficult to deform under low loads in comparison with the corresponding rubber mixings without reclaim might deform more easily under high loads. The practical importance of this fundamental difference in the properties of rubber and reclaim is difficult to estimate, but for some purposes it may be an advantage to have a material which moulds easily under high loads but does not alter in shape under low loads. Rubber manufacturers, however, have not suggested that there is difficulty in handling mixings without reclaim, and it seems likely that rubber without reclaim is sufficiently rigid under low loads for practical purposes.

Another striking difference between mixings containing reclaim and those without consisted in the extent to which they recovered from deformation. Reclaim is usually regarded as a "dead" material, and these experiments have confirmed that it reduces the "liveliness" of rubber mixings. This is a distinct advantage in manipulation, as it is easier to calender or extrude reclaim mixings to the required dimensions than similar mixings of raw rubber without reclaim.

On the whole the experiments have shewn that claims made on behalf of reclaim are too wide. It did not generally effect an economy in mastication and it did not improve calendering and

extruding. The only advantage which could be generally confirmed was that mixings containing reclaim are more "dead" than the corresponding raw rubber mixings without reclaim. It was also shown that good quality reclaim possessed advantages as regards deformation at high loads which it does not possess at low loads.

The main object of these experiments was not to test the validity of the claims made as regards the advantages of reclaim but to obtain quantitative data with a view to preparing raw rubber with properties similar to or better than reclaim.

There is one advantage of reclaim which it would probably not be economical for raw rubber to emulate. Owing to its origin reclaim contains considerable quantities of compounding ingredients. It is not likely that any proposal to incorporate a miscellaneous assortment of compounding ingredients with raw rubber in the East is likely to meet with approval, as manufacturers prefer to arrange their own compounding, and they have much better equipment for this purpose. Most of the compounding materials used are not produced in the East, and would therefore have to pay double transport costs if incorporated with rubber on the estates.

There are other directions in which it may be impossible or undesirable to duplicate the properties of reclaim. It has already been explained that, compared with crepe and sheet, reclaim is difficult to deform under low loads and easy to deform under high loads. This requires such a fundamental change in the nature of rubber that it is not likely to be obtained except by uneconomical means. There is the possibility that rubber could be hardened with compounding ingredients such as carbon black and rendered plastic with oil, and a patent has been taken out to prepare by this means a product resembling reclaim (Gaisman, E.P. No. 386,846, 1933). The process has the disadvantage that it involves the incorporation of compounding ingredients into rubber in the East.

It is possible, however, to imitate, and perhaps improve on the main virtue of reclaim, viz. deadness. This can be achieved by producing a more plastic and less elastic material. A more

plastic rubber would also have the advantage of requiring less mastication, more rapid extrusion, quicker calendering and easier moulding. It is considered that there would be a large market for this type of rubber, particularly if the vulcanising and ageing properties were maintained. Considerable progress has already been made in experiments with a view to producing this type of rubber, but so far it has not been possible to produce a type of rubber which will give vulcanised products under all circumstances equal in quality to those produced by crepe or sheet. The alternative is to compromise between vulcanising properties and ease of manipulation. There has been recently placed on the market a "softened" rubber (Ungar and Schidrowitz, E.P. No. 368,902, 1932) which is very easily manipulated and gives surprisingly good results under some circumstances when vulcanised. This product is prepared in Europe from crepe or sheet. What is needed, however, is a soft rubber with a distinctive and attractive appearance which can be produced economically in the East, and it seems likely that it is only a question of time before such a product is placed on the market.

Plate I. Gootee Method of Layering

Fig. 1. Layered branch showing bandage of earth tied with fibre.

Fig. 2. Bamboo containing water suspended from a branch above, showing rope (coming through a hole at bottom) along which water is slowly but constantly conducted to the bandage.

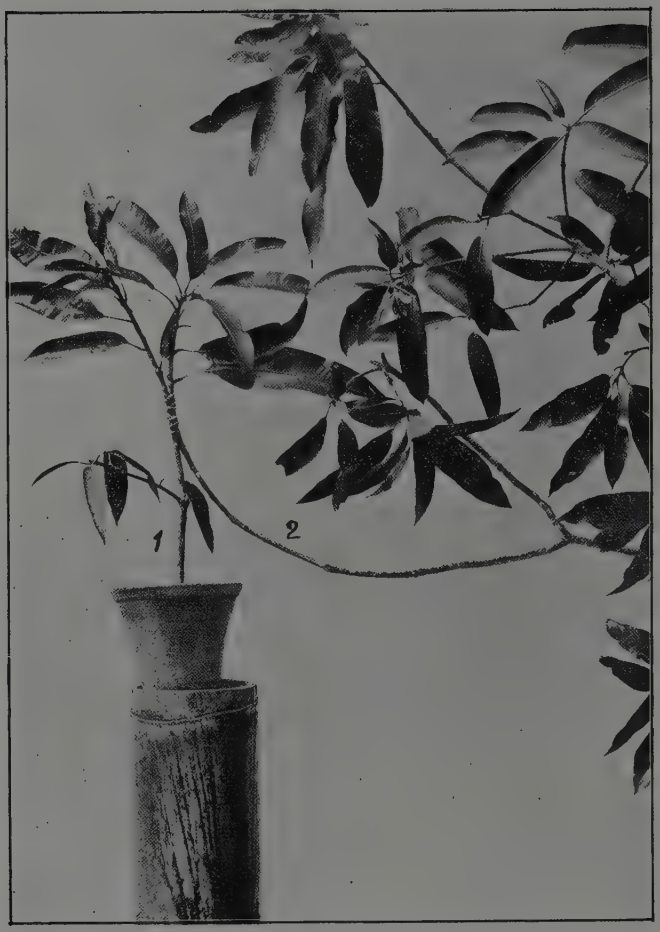

Plate II. Inarching the Mango

Fig. 1. Stock, or the tree upon which the scion is grafted.

Fig. 2. Scion (selected variety).

The junction is exposed to show method of tying previous to bandaging up with tape as described.

VEGETATIVE PROPAGATION

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THE common and most general way of propagating a plant is by the sowing of seed. While this is satisfactory in the case of a very large number of plants it does not apply to many of the better varieties of fruits. The method employed to reproduce and increase such fruits is termed "vegetative reproduction" and includes propagation by (a) cuttings; (b) gootee and layers; (c) inarching; and (d) budding and grafting.

A *cutting* is a part of a plant, usually a portion of a well matured branch, capable of producing roots and bearing an individual plant similar to its parent. To do this a clean cut must be made across a bud with a sharp knife and all leaves taken off to prevent evaporation of the moisture, or sap, in the cutting. When inserted in a soil of a sandy nature in a suitable temperature and degree of light and moisture, roots will form at the lower or cut end of cutting and a new plant formed. Some plants strike (form roots) most readily from quite young shoots called soft wood cuttings, others from partially ripened wood, some from a leaf with a bud at the base, others from shoots arising from the base of the plant, and a few, such as Begonias, from leaves or a portion of the leaf only. In general however the majority of plants propagate best from fully matured shoots, termed hard wood cuttings. The time to take such cuttings is when the parent tree has finished its growth and not when it is in full or partial growth.

Gooteeing, sometimes called marcotting, is a form of propagation practised a great deal in India and in China but now being replaced in most instances by budding and grafting. Where trees are difficult to propagate from cuttings the grower should select a firm healthy branch with well ripened wood and make a slanting cut immediately below a bud, placing a small stone in the grove of the cut to keep it open. Around the cut should be placed a large handful of prepared soil composed of one-third each of leaf mould, well-rotted cattle manure, and

sand. Tow, moss, or coir fibre placed around the soil and tied tightly will keep the soil mixture together. To help the branch to form roots at the cut and treated area it is necessary to cut out a small notch below the bandage increasing the notching each fortnight until 3 to 4 months, or sooner, if roots appear through the bandage, the branch can be entirely severed at this point from the parent tree. The monsoon periods are the best seasons for this operation, but should the weather become dry, regular watering should be given to keep the coir bandage and soil in damp condition. (Plate I).

Layering is a very similar method but it applies chiefly to those plants that are climbers or have low branches that can be bent down to the ground. The branch selected is bent down to the ground and cut slantwise across a node or bud as for gooteeing. The soil is removed where the cut portion of the branch touches the ground, the latter being then pegged into the ground and covered with a mixture of good leafmould, cattle manure and sand. Watering is necessary on dry days.

Inarching is a form of grafting by approach and the stock plant should be grown on in a pot so that it may be transported to the branch of the tree it is desired to propagate. A small slice of wood from one to two inches in length is removed from side of both the stock plant and the branch or scion it is proposed to propagate, and these are carefully fitted together and bandaged with tape or raffia grass, very tightly. The top of the stock plant above the union should be cut off, and that part of the scion branch below the union should be notched as recommended for gooteeing. When the plants have thoroughly united the branch scion is severed from the parent tree at the point previously notched below the union. (Plate II).

Grafting consists of various methods and termed *cleft*, *crown whip saddle* and notch grafting, but the usual and most common method is cleft grafting. All grafting (and inarching) consists of placing together two cut surfaces of the same or nearly allied variety of plant to cause these to unite and grow together into one plant. The root portion is the stock and that desired to form the head of the tree is the scion.

In cleft grafting, the head of the stock is cut across horizontally when of pencil thickness or more. The top of the stock is then split at the top in a vertical direction to the depth of an inch or more according to the size of stock that is being used.

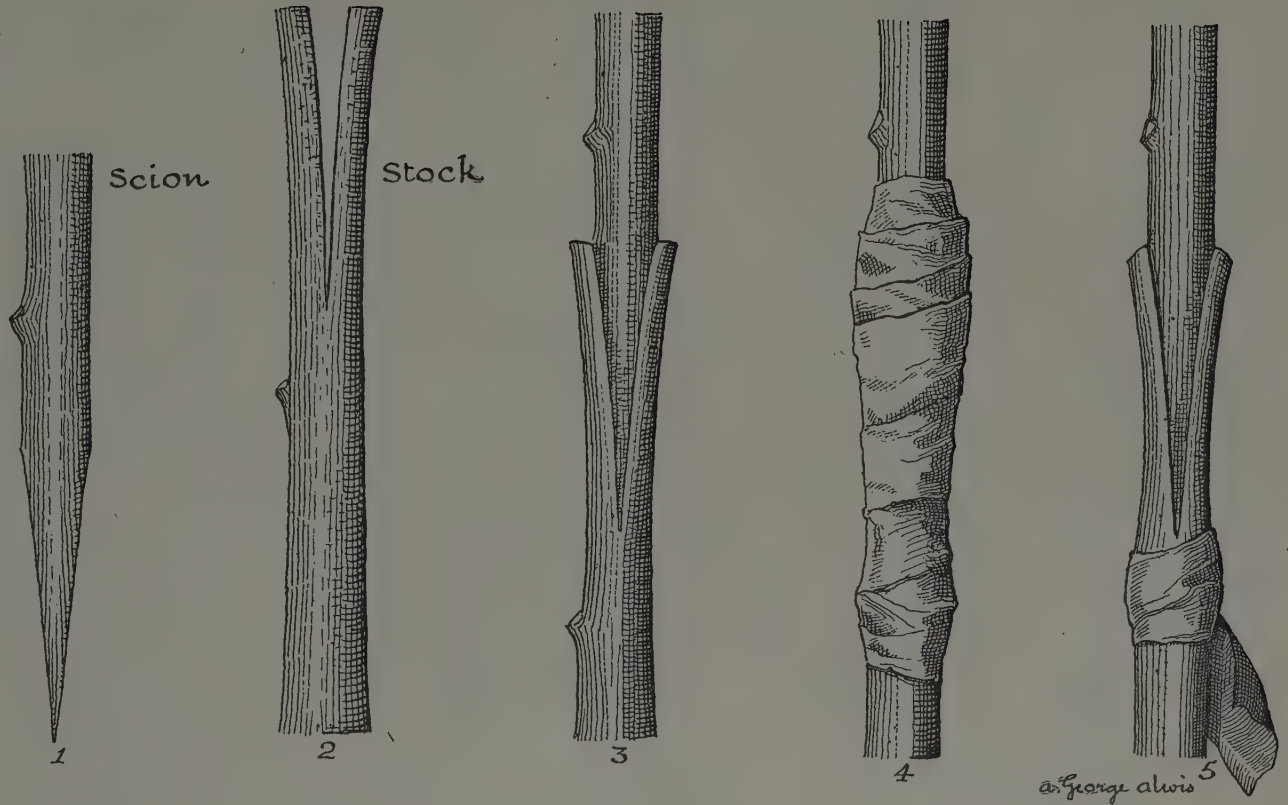

Plate III. Cleft Grafting.

Fig. 1. Scion ready for insertion. Fig. 2. Stock. Fig. 3. Scion inserted in position.
Fig. 4. Bandaged stock after insertion of Scion. Fig. 5. Bandage removed to show early stage of healing.

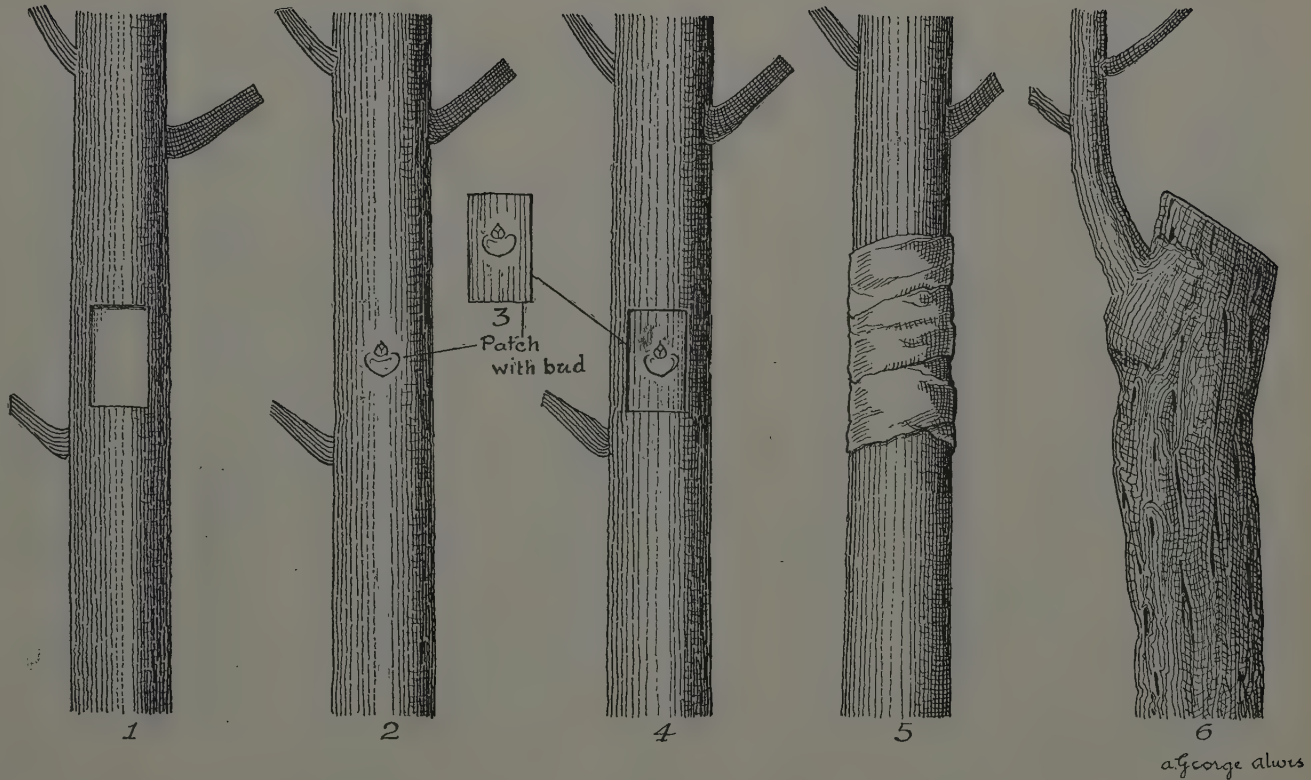

Plate IV. Patch Budding.

Fig. 1. The Stock. Fig. 2. Scion showing bud. Fig. 3. Patch with bud. Fig. 4. Patch inserted on stock. Fig. 5. Bandaged stock after insertion. Fig. 6. Growing bud several weeks later.

The scion is then cut away at the base to form a wedge in shape which is fitted carefully into the split stock. Both stock and scion must be of equal thickness, as shown in diagram. (Plate III).

The joined area is then bound up tightly with waxed tape to exclude air and moisture, and at Peradeniya the greater portion of the scion to below the junction with stock is protected by waxed paper tied round the stock and scion to assist further in the exclusion of moisture and air and to check evaporation or damage from the direct rays of the sun. The operation is best carried out in cloudy weather and the knife used for the operation must be a sharp one.

Budding is performed in several ways termed the *patch*, (Plate IV) *shield*, *T budding* and *inverted T budding* (Plate V). The operation of budding consists of inserting a single detached bud underneath the bark of the stock. The shield and patch budding method is usually employed for larger stocks such as rubber and mangoes and the T methods mostly for citrus, roses and such like where the stock plants are usually smaller at the time of budding. The correct time to bud is when the bark of the stock and scion peel readily. The piece of branch from which the buds are taken is known as the bud stick and this is in most cases of the previous season's growth and which possesses good plump buds. The stem of the stock should be straight and clean, and a T or inverted T shaped cut made through the bark of the stock to the wood, the size of cut varying according to size of stock used and the size of the bud and bud shield used. One to one and a half inches is the usual length of the downward cut and a half to three-quarters of an inch for the cross cut. The bark is then lifted and loosened with the flat bone end of the budding knife and is then ready for the scion bud. The latter should be cut from the stick by passing a knife diagonally under the bud so as to remove the bud, and part of the wood and bark, called the shield. The bud is then inserted in the place prepared in the stock and tied firmly with waxed tape. At the end of about two weeks the bandage is removed; and if the bud is found to be alive, the bandaging is redone so as to leave the bud alone exposed. Overhead shade is necessary for a time, the best time to bud being during light showery to fine weather. In time of drought or heavy rainy periods the percentage of success is affected adversely.

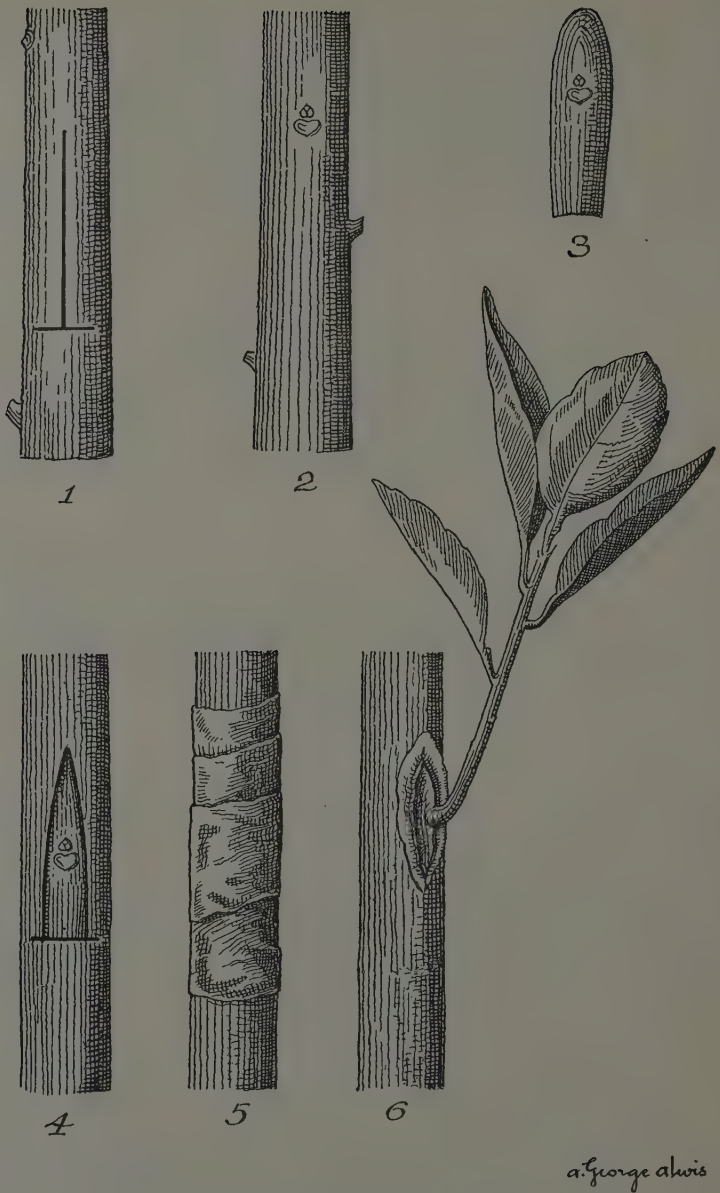

Plate V. Inverted T. Budding

Fig. 1. Inverted T. cut on stock. Fig. 2. Scion showing bud. Fig. 3. Bud shield removed from scion. Fig. 4. Stock with bud shield inserted. Fig. 5. Bandaged stock after insertion of bud shield. Fig. 6. Growing bud. Note formation of callus.

CACAO BEANS AND *EPHESTIA ELUTELLA**

INTRODUCTION

CONSIDERABLE attention is being paid at present to the problem of the insect infestation of stored products. One of the chief pests studied in this connection in temperate regions is the moth *Ephestia elutella* which constitutes a menace not only to the cacao bean but also to many other types of stored products. In the following paper the life and habits of this pest, especially in relation to the cacao bean, are recorded in the hope that they may throw some useful suggestions towards its control.

LIFE-HISTORY

Ephestia elutella, a small grey moth, and a weak flier, lays its eggs singly, or in twos or threes, generally attached by a weak gummy solution, in small crevices—a crack in a wall, a fold or seam of a bag, or a crack in the shell of a bean. Occasionally it lays them loosely on the floor or on any available surface. These eggs hatch into minute larvae which wander off in search of food but as their need for sustenance is not immediate they may spend a day or two in search of a suitable feeding ground. Thus, the exact place of the egg-laying is of secondary importance. The larva can enter any hole or crack which is not less than $\frac{7}{1000}$ inch at its narrowest point, the limit to the size of the hole being its head size, as this is of unyielding chitin, whilst its body is soft and pliable and can be pulled through an even smaller hole. During its preliminary search for food the larva has apparently two objects, firstly, to seek a sheltered spot where it can live undisturbed, and, secondly, to find food which is sufficiently soft for its newly hatched and tender condition. The latter is important, for although the nib of the bean is not too hard to be attacked, the shell of the fermented bean will be shown to be too hard for this attack. Having found suitable food, it will settle down in some sheltered spot for its larval life period.

The amount of food consumed during the larval stage is variable but on the average amounts to 0·3 to 0·6 grms. It takes two or three larvae to consume the whole of the nib of an average cacao bean. The larva's diet is very varied. Hardly any foodstuffs come amiss—dried vegetables flour or biscuits, dried fruits, etc., are all suitable. Its food even consists of other dead insects, including its own parents. It has been bred throughout its life-history on dead *Tortrix viridana* which shows that even in an empty store many will survive unless there is absolute cleanliness.

The larva's subsequent pupation and its emergence as a moth need not be detailed, though there are many interesting points in these periods of its life-history.

* By Raymond V. Wadsworth in *The Tropical Agriculture*, Vol. X, No. 4, April 1933.

TYPES OF BEANS ATTACKED BY *E. ELUTELLA*

Variety

As a result of the examination of many lots of infected beans, and also of experimental work, it has been found that the nib of the Criollo bean (i.e., beans with a light red-brown nib and generally softish in texture), is more readily attacked than the nib of the Forastero bean (i.e., beans with the purple and hard type of nib). The more open texture of Criollo cacao and its comparative softness, together with, probably, the slightly higher sugar content due to short fermentation, perhaps make this type of cacao more liable to insect attack. Moreover, its brittle shell is, through cracking, more likely to provide access to the cotyledons. Thus the old finer grades of Ceylon, Venezuela and Samoa cacaos will keep poorly in an insect-infected warehouse.

UNFERMENTED CACAO

Generally speaking, unfermented beans have a soft shell with some adhering pulp; such a shell can be attacked by the newly-hatched larva. Beans of this character provide little seclusion as the cotyledons are close, but the larva is not starved as it can subsist handsomely on the pulpy shell and in the absence of shelter makes the best of it. In the case of a bad attack by *E. elutella* it sometimes happens that the unfermented beans will be completely denuded of their shells, whilst the cotyledons are only slightly attacked on the surface. *E. elutella* seldom bores a hole for itself into the body of the bean, but just channels the surface on which it lives. This feeding on the shell is an interesting variation in the method of life of the larva. Under normal conditions it settles down in one place and spins a silken tube in which it lives and from which it can easily reach all the food it will need. In the case of a larva feeding on shell, the food is obviously not very congenial and the larva moves a lot. The silk is consequently not so noticeable, seldom being formed into a tube. It may take the shell of three or four beans to provide the food for one larva.

Guayaquil cacao always contains a large percentage of beans of this type and parcels from time to time show the damage characteristic to unfermented cacao. Experimental confirmation of this has been obtained. A bag of beans containing a percentage of unfermented cacao was infected with *E. elutella* and after the breeding of two generations the bag was examined. All the unfermented beans had their shells almost completely removed, whilst none of the fermented beans had been attacked.

Machala and Grenada cacaos exposed under similar conditions showed that in no case had the Grenada cacao shell been affected, whilst the Machala beans had 49 per cent. with their shells attacked 30 per cent. showed attack on the shell alone, and 19 per cent. some attack also on the nib.

This point is further illustrated in subsequent tables.

Unfermented beans having close cotyledons, between which a larva cannot crawl, are never attacked internally, like fermented cacao.

Washed unfermented beans differ considerably in that the washing removes the soft pulp and leaves a much harder shell. The attack by *E. elutella* is found to decrease with the degree of washing.

BROKEN, CRACKED AND GERMINATED BEANS

Except in the case of Guayaquil cacao, unfermented beans are met with only in poor quality cacaos. As a general rule this type of defect is disappearing and so does not vitally concern most growers. Many cacao parcels do, however, contain germinated and broken beans or beans with cracked or cut shells, and it is these that constitute the most serious cause of insect trouble. In a general way it might be laid down as a rule that the proportion of such beans represents the maximum infestation a sample may attain.

It has already been stated that the newly-hatched larva of *E. elutella* searches for easily available food and that it cannot attack hard surfaces. The shell of a normal fermented cacao bean provides such a surface, and the only hope of obtaining the food inside is through the finding of a crack or hole. To test this a small sack holding about one pound of beans was placed in a closed space infested with moths. The moths laid eggs and in time a second generation was produced. The infection was a bad one as plenty of moths were used to provide eggs for the preliminary attack. The beans were examined individually and divided into those showing original cracks or holes in the shell and good whole beans in which no such cracks could be observed.

The different types were then individually cut open to determine the extent of infection in each. The results were as follows:

TABLE I

	Beans with crack or hole in shell	Beans without crack or hole in shell
Insects attacked ...	84%	... 2%
Unattacked ...	16%	... 98%

Possibly even more striking results were obtained in the case of different lots of beans subjected to long storage in precisely the same conditions. Two experiments were carried out, the separate lots in each being kept under one cover, but divided by card partitions and arranged in a circle so that each had the same chance of infection. The infestation was carried out by the introduction of moths in the usual way. The breeding was allowed to continue undisturbed for nearly two years. In the case of Experiment I (Table II) so much food was available that even after two years it was still full of insects at different stages, but mostly in the larval form. In Experiment II (Table III) practically no living insects were left, one or two larvae alone being found during the examination. One experiment was therefore carried on so long as all available food was consumed and the insects died of starvation, whilst the other showed an infection in its heyday.

In Experiment I Accra nib was also included. Being very easily attacked, it contained a large number of larvae, and by the time the experiment was concluded 45·5 per cent. of it had been completely consumed. The inclusion of nib shows how readily available beans are in this form. The roasting of beans cracks a large proportion of the shells and the small percentage attacked is due to the large amount of food available.

Machala beans stand out in having a high percentage of beans showing no visible crack in the shell, attacked. All these beans were soft-shelled and the attack was confined to the shell.

TABLE II

Beans Attacked by E. Elutella under Conditions of Plenty

Types of Cacao	Beans with Visible Crack in Shell	Beans with no Visible Crack in Shell	Shells showing Visible Cracks		Shells showing no Visible Cracks	
			Attacked	Not attacked	Attacked	Not attacked
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Raw Grenada	4	96	76	24	·5	99·5
Raw Bahia	18	82	92	8	nil	100·0
Raw Accra	20	80	90	10	3	97
Raw Machala	16·5	83·5	90	10	12	88
Roasted Accra	47	53	58	42	5·5	94·5

TABLE III

Beans Attacked by E. Elutella Showing the Limits of Available Food Supply

Types of Cacao	Beans with Visible Crack in Shell	Beans with no Visible Crack in Shell	Shells showing Visible Cracks		Shells showing no Visible Cracks	
			Attacked	Not attacked	Attacked	Not attacked
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Raw Accra	37	63	93	7	nil	100
Raw Accra	23	77	94	6	2	98
Mouldy Accra	37	63	100	nil	nil	100
Germinated Accra	100	—	100	nil	—	—
Raw Machala	32	68	100	nil	6	94
Average	45·8	54·2	97·4	2·6	1·6	98·4

The high percentage of unattacked beans in the Grenada sample with cracked shell is interesting and is due to the fact that these shells, though cracked, fitted tightly over the cotyledons and so did not readily provide shelter for the larvae which sought the more easily available food present.

In Experiment II the percentage of cracked beans was very high throughout. By the end of the experiment, however, practically no life was present, and it will be seen that this occurred only when the cracked beans had been consumed. The few cases where cracked beans were not consumed were instances where the shells fitted very tightly over the cotyledons, preventing the access of the larva. There were still plenty of beans, but the food was protected by the shell and in a land of plenty the larvae died for want of the strength to get the food. Every germinated and cracked bean was completely consumed, so that the shell was the only thing left to represent the bean—its inside being full of frass. The Machala cacao was a sample of well-fermented beans for that class, with only a few soft-shelled beans. It will be noted that these were attacked, though they naturally showed no crack in their soft shells.

Amongst wharfingers in England who store cacao for brokers, sometimes over many years, there is a belief that old cacao is immune from insect attack. Practical experience has shown them that some old parcels of cacao do not breed moths. This is quite in accordance with the results which are given above as the small quantities of available food in parcels of beans containing few cracked or broken beans would, in a badly infected store, be quickly consumed. When once these had been eaten, no other food being available, the parcel would remain immune from further attack.

POSITION OF SACK AND MOTH EMERGENCE

At times it happens that the infestation of a parcel of cacao beans seems much greater than that suggested by the moths or larvae seen in the store. When this occurs it will be found that the sacks are stacked on end one or two high only. A sack of beans is never filled absolutely full as otherwise the bags would not stack well on their side and the chance of bursting during rough handling would be great. This means that a sack on end has at the top a fairly large free space. When the larvae enter this they sense that here is sufficient space for the future moth to fly and meet a mate. They, therefore, do not wander much further, but, finding a suitable space for pupation, spin up. As this occurs inside the sack, the cocoons are never seen. The moths hatch inside the bag and find sufficient space for flying and mating. The next generation is thus produced hidden from view and the store appears comparatively free from insects owing to only a few larvae forcing their way out of the sacks. Moths which hatch inside the sack cannot get out into the store since at this stage the insects are too frail to force an exit. It is at the larval stage only that this occurs. There is a belief amongst some that the moth does force its way outside the sacks and this was tested, with the following results. Small sacks, made of the usual sack material, three-quarter filled with beans, were placed on end (so as to induce the moths to pupate inside the sack) whilst some were placed on their sides leaving no free space in the sacks, and infected. All these moths were removed from the test as soon as they were dead. After two generations had been fully completed, it was found that every moth in the free space outside the sacks had come from a pupa outside the sacks, whilst the moths inside the sacks had lived and died in their prison, and a pupa for each was inside the sack. Thus moths inside or outside the sacks had hatched from pupae in their respective areas and the insect, as the fully hatched moth, could not move out of the sack in which it hatched. Sacks placed on end constitute a hidden danger to a store, and all sacks should be placed on their sides, when the beans fill all the free space.

METHOD OF ATTACK

The method of attack of *E. elutella* will now be quite clear. The moths lay their eggs in the neighbourhood of the beans, generally on the outside of the sack or in its folds. The young larvae hatching must wander for a little time before settling down. During this period the aim of the larva is to find some suitable food which, whilst being soft enough to attack, also provides some shelter, in which it will remain hidden. In the case of the cacao bean, it finds a crack or hole in a loose shell and crawls into the space between the two cotyledons. Here it lies in the midst of plenty, hidden from view and well protected, and until fully fed when it

will have consumed about half a normal bean. Generally by that time the hole through which it entered is too small for the grown larva to get out by and so it eats the shell away in the form of a circular hole and escapes to pupate. If the sack is on end the free space in the sack induces pupation, which frequently may take place there. With normal stacking the larva forces its way through the holes of the sack into the open air, when it soon finds a suitable place to pupate and the life cycle commences again.

CONCLUSION

It has been shown that the cacao bean properly fermented and with its shell intact is proof against the attack of *E. elutella*.

The damage caused by this insect is due to the presence of defective beans in the parcel—partially cracked, germinated and broken beans. Cut and unfermented beans are a further source of infection.

Buyers of cacao beans may take as a guide to the maximum possible infection the amount of such types present in any parcel of beans.

Criollo beans are more susceptible to attack than Forastero beans under the same conditions.

Unfermented beans are attacked externally, the soft shell being removed by the larvae.

Sacks stacked on end with a free space at the top of the sacks encourage larvae to spin up inside the sack and so breed hidden from sight. This does not occur with sacks stacked on their sides.

PRACTICAL APPLICATION

Beans

The defects in the cacao bean which have been shown to encourage the infection with *E. elutella* are also defects which the manufacturers dislike for other causes. Mostly they are defects which have to be guarded against on the plantation. The classes of beans which should be reduced to a minimum are here arranged in relation to *Ephestia* attack, the least important being given first:

Unfermented beans.

Cut beans.

Cracked beans.

Germinated beans.

Broken beans.

Unfermented beans are generally a sign of inferior preparation and should be fairly easy to guard against.

Cut beans may be caused when:

(1) Opening the pod.

(2) Turning during fermentation and drying.

Cracked beans are caused by rough handling after drying. Over-fermentation and washing of beans are to be guarded against as prolific sources of this defect. Unnecessary walking over the beans should be discouraged on this account.

Germinated beans are due to poor picking, leaving too long before fermenting or imperfect fermentation.

Broken beans should be separated from the cacao before bagging. They represent the most serious defect. The less the planter is able to produce of these, the less risk there is of cracked beans also being present in the bulk.

Buyers and brokers should consider these defects, particularly the last one, as a guide to the keeping qualities of any parcels offered to them.

STACKING

The position of the sack does, to some extent, affect the infection of the beans. It has been shown that the correct position of a sack is on its side, when no free space is available to induce the larvae to pupate inside the sack. This position will prevent the hidden breeding of *E. elutella* and enable a storekeeper to see better what infection is present.

STORES

The diet of *E. elutella* is very varied and it has been shown how the moth may continue to breed on most unlikely material, such as other dead insects. Absolute cleanliness is, therefore, advisable in every store. Regular brushing and whitewashing of walls and roof should be carried out and the more inaccessible the spot, the greater care which should be taken in cleaning.

ACKNOWLEDGMENT

The work was carried out in the Research Laboratory of Messrs. Cadbury Brothers, and I wish to express my thanks to the firm for permission to publish the results.

ROTATION CROPS*

"ROTATION of crops" has become a byword in present-day systems of arable farming. The reasons are patent and need but little discussion here, save to point out certain factors which make varied cropping specially advisable under South African conditions.

It is obvious that on land where the same crop is grown continuously the soil will, in time, become denuded of those elements of which the crop requires most. This impoverishment of available constituents will take place more quickly than the working down of the dormant, non-assimilable material into a state suitable for absorption by plants. It is therefore well to crop land with species of varying requirements so that a "balanced" demand is made of the soil, adopting the principle that a crop requiring much phosphorus, for instance, be followed by one requiring less phosphorus, and more of the other ingredients, such as potash or calcium.

Crops with different types of root systems, shallow and deep, for example when used alternately will help maintain texture and fertility, functioning in varying layers of the soil and subsoil.

Rotation of crops is of importance in minimizing damage by pests, both of the root and aerial portions of the plant. A small black beetle (*Syagrus rugifrons*) has done serious damage to cotton crops in South Africa, working below ground level and practically destroying root systems, the only remedy being a change of cropping. Work at Barberton on insect pest control has shown that American Bollworm (*Heliothis obsoleta*) seems to prefer maize as a host plant to cotton; the pest does relatively little harm to the maize, and as this crop seems definitely attractive to one of the cotton-grower's worst enemies, there should be some incentive to him to include it in his cropping scheme if for no other reason than to act as a trap crop.

In a country of erratic rainfall and general climate, such as South Africa it is of importance to the farmer to have a range of useful crops. With constant liability to late rains, making the planting of long-period crops inadvisable, or to crops being wiped out by hail or wind early in the season, he does not want to have "all his eggs in one basket". With a long-period crop such as cotton (six to seven months) he may require something to plant on odd lands after his cotton-planting is finished; or should his cotton suffer irreparably from the elements, he may wish to replant his lands with some crop late in the season, say December or January. Bearing these factors particularly in mind, the aim at Barberton has been to pick out strains of various crops capable of maturing in a fairly short time (three to four months).

* A discussion by W. L. Fielding, B.Sc., Dip. Agric., in *The Empire Cotton Growing Review*, Vol. X, No. 2. April 1933, based on work carried out at the Cotton Breeding Station, Barberton, South Africa, on the question of suitable rotation crops for inclusion in a cropping scheme having cotton as the main cash crop.

The provision of home-grown food for native labour and cattle rations is an incentive to the growing of certain leguminous and cereal crops on a farm where cotton is the main crop.

Apart from home-consumption, the selling of produce both on interior and export markets is one of the most difficult problems to be faced. Crops yielding produce adapted to market requirements are naturally being selected, but prevailing low prices make the introduction of these into a farming scheme very slow work. Owing to market prejudice some crops possessing desirable agricultural characteristics are debarred from extensive use by the farmer. For instance, a bean which is suited to conditions and is high yielding may be considered on the small side for native consumption or for the canning trade, whilst a rather larger relative fetching a high price on that market may be a poor proposition for the farmer owing to low yielding potentiality or susceptibility to insect pests. The beans may be of equal actual feeding value and of similar taste, there being no real rhyme or reason for the market preference save conservatism or the appeal of a larger, perhaps coloured, bean to the eye.

An extensive range of crops have been tried on the Corporation's South African stations, including maize, soya beans, sunflower, groundnuts, sorghums, and a miscellaneous range of legumes having possibilities. Following are brief notes on the agricultural and economic value of some of these crops, the selection of the most useful strains, and the fitting of them into a farming scheme having cotton as the main cash crop.

MAIZE *(ZEA MAYS)*

"Mealies" have long been a standby in South African cropping schemes. The Union's main crop is grown on the Highveld, and whilst much progress has been made in the breeding of suitable varieties for these areas, little attention has been given to maize problems on the Middleveld and Lowveld, in which areas the main cotton belt lies. On the Highveld, varieties of the white flat type (*indentata*) predominate. These are long-period maizes (140 to 150 days), and if put in late on the Lowveld often produce a poor crop. It is probable that in the Barberton area maize will be grown rather for purposes of food for native labour and cattle than for export. The need is then for a white-grained maize suitable for grinding into "mealie meal", the standard native foodstuff, the selected variety being capable of maturing a satisfactory crop in a comparatively short period. Out of a large variety of maizes tried, a White Flint strain, which has been under observation at Barberton over three seasons, has so far seemed best suited to requirements. Last season it definitely proved its yield capabilities in a variety trial. White Flint produces a round white grain which crushes into a meal apparently very acceptable to the native palate. It belongs to the *indurata* group, which are of a shorter maturation period and more drought-resistant than those of the *indentata* group.

White Flint grain is of a lesser market value than grain of the large white flat type, such as is produced by Hickory King or Potchefstroom Pearl; these latter would probably be grown by a man out to farm maize as the principal crop. The main question, however, being that of rotation crops for the cotton-grower, who will give prior attention to his cotton (and in some cases tobacco), White Flint has been selected as

probably the most suitable all-round type for a cotton-grower wishing to plant maize after his cotton, with a fair chance of obtaining a reasonable crop for feeding his native labour, even in an adverse season. About two tons of White Flint seed have been supplied to farmers in the Barberton area. It is also being grown on the Corporation's stations in Swaziland and Natal.

A maize of possible use, should export produce be required, is a small red-grained, Peruvian type. Points in its favour are early maturity, high resistance to the "streak" virus disease which causes serious reduction in yield in very late-planted maize in this area, and its production of a grain well suited to United Kingdom markets.

SOYA BEANS *(GLYCINE MAX)*

The produce from this crop has great possibilities in the commercial world. The uses to which soya beans can be put include the manufacture of soft soaps, paints, linoleum, water-proofing liquid, toilet powder, enamels and waterproof goods. The residual "soya cake", after oil extraction, forms valuable cattle cake. Several firms in England and on the Continent are now producing soya products for human consumption, the basic soya flour for these edibles being prepared by the Berzcellar process.

A very large number of soya bean varieties from different parts of the world have been tested on the Corporation's South African stations. Several have shown good yielding capabilities, but only one has proved of real use as a grain producer. This is the Barberton Y 1 strain, producing a fairly large, bright yellow bean, and owing its superiority to a high degree of resistance to shattering of grain when ripe. Oil content is in the region of 18 per cent. The beans make an attractive sample in appearance and are likely to prove generally acceptable from the market point of view. South African produce of this type has recently been reported on very favourably in comparison with the Manchurian soya beans customarily tendered on United Kingdom markets.

The soya bean has one big advantage in that it is the only bean crop which is not liable to serious damage by the large Cantharides beetle. This pest will often destroy the majority of the flowers on bean crops with exposed flowering systems; the flowers of the soya bean are borne in the axils of the branches and apparently owing to this obscurity within the foliage of the plant never suffer seriously.

Experiments at Barberton are giving useful information on the best spacing at which to grow soya beans, and on the best time to plant. Although South African soils as a whole are not considered deficient in nitrogen, there is always the need for keeping up nitrogen content on continuously cropped lands. It is this function which the leguminous crop in any rotation is expected to effect. In order that the soya bean shall fulfil this purpose, it is essential that the bacterium specific to the soya plant be present in the soil, so that it may infect the root systems and, working in "symbiosis" with the plant, fix nitrogen from the soil, air and moisture. The soya bean bacterium is not indigenous, and cultures have been imported with which to inoculate crops. A method of inoculating on a field scale with soil cultures of bacteria by means of a fertilizer attachment mounted on the planting machine is being tried out. The

question of the influence of lime on the effectiveness of the bacteria and on the general growth and yield of soya beans is being investigated. An acid soil condition is known to be unfavourable to the bacteria, and it is a question of whether more satisfactory inoculation and thence nitrogen fixation would justify a farmer liming his lands.

The soya bean seem suited to Barberton area conditions and may prove a useful crop when produce markets recover. During 1932 there has been a sale of twenty-seven tons of Y 1 soya from various growers to an oil-extracting company on the Rand. The price was naturally a low one, based on current London quotations, but such beginnings might later lead to the provision of a definite interior market for soya beans.

SUNFLOWERS

Some work has been done on spacing and the selection of an early maturing, good yielding strain of this crop. Sunflower seed is saleable in the interior for poultry food purposes, is exported in small consignments to Australia, and can be utilized on the home farm as crushed meal in the concentrate ration for dairy cattle. It is fairly drought-resistant, apparently immune from any serious pest or disease in this district, and is easily handled.

GROUNDNUTS

Suitable varieties have been selected, but the crop does not appear to have great possibilities for the cotton-farmer in this area. In order to obtain a good return, it seems probable that the crop should be planted in October or November, owing to the subsequent serious incidence of "rosette" (virus) disease. This question is being further investigated in time-of-planting experiments, but a crop which required to be planted at the same time as cotton would be less useful than crops capable of later planting.

MISCELLANEOUS LEGUMES

A range of leguminous crops of suitable growth duration for fitting into a rotation with cotton are under observation. Apart from rotational value, they have varying uses, such as providing dried beans for home consumption as cattle food and native labour rations; for sale on interior and possibly overseas markets for native or European consumption; or the provision of a mass of foliage to be cut as cattle fodder or ploughed in as a green manure.

A small white bean, tepary (*Phaseolus acutifolius*), has proved the most prolific yielder in this class, and is well suited to requirements, maturing in two and a half to three months. Tepary bean is a native of Texas and Arizona, where it is reported an important crop. In the crushed form it should prove a useful component of concentrate rations for cattle. In the cooked form it appears acceptable to the South African native's palate. A gold-mine in the Barberton area feeds tepary beans to its native labour. Where labour gangs include a proportion of natives belonging to a non-meat-eating tribe, the question of supplying proteins by feeding a bean ration becomes of importance. Good germination of this bean can be obtained under only moderate moisture conditions, the crop being quite an easy one to handle throughout.

Various kinds of *Phaseolus lunatus* (Lima, Madagascar, or butter beans) are being tried. They seem to have possibilities planted toward the end of the rains, and are worthy of extensive trial as they command a far higher market price than many beans, on United Kingdom markets, for European consumption.

Certain beans of the *Phaseolus vulgare* group (speckled sugar beans, large kidney beans, etc.,), command good market prices, but so far have shown little promise of being more than odd crops in this area.

It has not been possible to do any definite work at Barberton on the effects of green manuring on ensuing cotton or maize crops, but sunnhemp (*Crotalaria juncea*) is probably about the most useful crop, sown broadcast and ploughed in at 2 to 3 feet high. It has an added advantage in that a group of bacteria capable of infecting the roots of sunnhemp are indigenous in the Barberton soil, so that besides acting as a green manure, the crop may be beneficial from the nitrogen point of view.

Types of velvet bean (*Mucuna*) have been found to produce a good crop for hay and green-fodder purposes.

POSSIBLE ROTATIONS

Two experiments have been laid down at Barberton this year in which cotton will follow cotton, soya bean, tepary bean, maize, sunflower and fallow respectively. The experiments are laid out as random blocks. The strains of crops used are those which seem most likely to prove the best standard lots, and it is intended that the trials shall be more or less permanent, so that studies of the growth of cotton after cotton itself, after one year fallow, and after the various rotation crops may be made. The preliminary stages in the work of ascertaining what crops can be grown, the best spacing at which to grow them etc., having been done, it is now for these rotation experiments to demonstrate the merits of the various crops.

TOBACCO

Tobacco is an important crop in the area, "Barberton snuff" being in demand by natives throughout the Union. Those farmers having good tobacco lands and sufficient irrigation water will probably adopt a simple tobacco-cotton-tobacco rotation. This is a specialized side of farming, however, and the Corporation's work on rotations has therefore been directed towards the finding of crops for wider areas, and for lands where tobacco will not normally be grown.

SUMMARY NOTE

It appears probable that maize and soya beans will prove useful standard crops; maize as a feed for native labour, and soya bean as a cash crop either on interior markets or, with more settled world conditions, for export. Beans suitable for native and cattle feed, or for the European dried bean market, may have places in the farming scheme, as also oil-producing crops (apart from soya bean), such as sunflower and groundnut, the former with the further possibility of immediate use as a cattle or poultry food, the latter for sale to natives locally. Farmers having a dairying business will need to include a certain amount of green fodder in their cropping scheme, and for the ordinary arable farmer the provision of pit silage, made from a broadcast crop of sorghums or maize, will prove useful for draught oxen when the dry season is a long one.

THE PROBLEM OF THE LOCUST*

FORTUNATELY for the cane sugar industry, the areas of major production lie outside the belts of intensive destruction by locusts. Nevertheless, practically none are free from all danger; in a few, severe invasions are not unknown while extending cultivation may easily add to the number of these latter. The main features of the locust problem, consequently, will be of interest to many of those engaged in the cultivation of cane. Much money has been spent in those countries subject to invasions in organizing control measures but, owing to lack of adequate knowledge of the habits of the insect and to the fact that such control is necessarily limited to the area where the flight descends, these measures aim merely at a cure. Effective control can only arise from prophylactic treatment—when the origin of the swarms and the causes of their intermittent appearance have been determined. Then it may become possible to devise a true prophylactic remedy in arresting the formation of the swarms. In recent years considerable advances have been made in that preliminary knowledge of this group of insects and the day when the locust menace will be brought under full control is perceptibly nearer.

The term "locust" is a popular one, without scientific definition. The word calls forth visions of flight which obscure the sun, of insects settling in such vast numbers that every green blade disappears as by magic, of armies of "hoppers" marching across the country. Popular terminology, again, applies to a group of very similar insects which occur as solitary individuals, the name grasshopper; and in broad outline, the distinction is a real one. But difficulty arises when a more scientific definition is sought. Scientific definition aims at classifying organisms into species to which individuals may be referred through the possession of definite characters. When a detailed study of the group, the *Acrididae*, was undertaken with this object, it was found that, while the individual locusts and grasshoppers were readily classified, locust from locust and grasshopper from grasshopper, no such ready distinction could be drawn between locust and grasshopper. Between one species of locust and one species of grasshopper a number of intermediate forms occurred which linked the two into a continuous series. To B. P. Uvarov belongs the credit of supplying the explanation of this observation. The linked forms of locust and grasshopper, in their characteristic expression so distinct that separate specific names have been applied to each, are merely two phases of the same insect, in other words, that the insect lives in the solitary phase for a number of generations when it possesses all the morphological characteristics of the grasshopper, and then suddenly passes into the gregarious space when it exhibits all the morphological characteristics of the locust, while intermediate forms appear at the change of phase. This view, at first advanced tentatively by Uvarov

* From *The International Sugar Journal*, Vol. XXXV, No. 413, May 1933.

in 1921, has since received confirmation from many sources. Though the two forms of all the locusts of economic importance have not been determined with certainty as yet, there appears to be no reasonable doubt that there is here a general phenomenon and that the periodicity of the locust swarms is linked with this occurrence of two phases. The major instances now recognized are given in the following tabulation:

	Locust.	Grasshopper.
The Moroccan Locust	*Dociostaurus maroccanus*	(?) ph. *degeneratus*
Area.—Mediterranean Region to Turkestan.		
The Migratory Locust	*Locusta migratoria*	ph. *danica*
Area.—Old World S. of 60° N., N. Australia and New Zealand		
The Desert Locust	*Schistocerca gregaria*	ph. *flaviventris*
Area.—Africa excl. humid and forest regions, E. to the Punjab.		
The South American Locust	*Schistocerca paranensis*	(?) ph. *americana*
Area.—Indefinitely S. American, West Indian Islands, N. to Mexico.		
The Brown Locust	*Locustana pardalina*	ph. *solitaria*
Area.—Parts of South Africa		
The Red Locust	*Nomadacris septemfasciata*	ph. *coangustata*
Area.—South Africa to the Congo, South Sudan and Abyssinia		

Another locust of minor importance economically is the Italian Locust, *Calliptamus italicus*, which occurs in the Mediterranean region including Egypt. It is a species which only occasionally swarms and little is known about its phases. There are also a number of other species of grasshoppers which have the capacity of swarming occasionally, among which may be mentioned the Bombay Locust, *Patanga succincta*, and the Javanese Grasshopper, *Valanga nigricornis melanicornis*. Lastly, there are numbers of solitary grasshoppers which appear to have no swarming phase though some of them may appear in numbers which constitute a serious pest. Among these the most important is *Oxya chinensis* (*O. velox*), one of the smaller Rice Grasshoppers, which does much damage to rice but, in Hawaii, is a serious pest of sugar cane.

METHODS OF CONTROL

Until the phase theory came to receive general acceptance only a few years ago, control was limited to attacking the swarms where and when they occurred. It was recognised that swarm breeds swarm and, consequently, only by attacking the early swarm could a succession of swarms be prevented. The measures adopted were essentially remedial, for they only became operative after the appearance of the first swarm with its attendant destruction, and too little was known regarding the origin of the first swarm to permit active measures being organized for its destruction, at its source. In several countries, notably South Africa, a complex organization for the purpose has been developed. The problem is essentially a practical one and behind it lies the question of cost. The various methods commonly adopted and the principles underlying these may be of interest.

Mechanical Methods.—The various mechanical methods concentrate, as a rule, on attacking the insect at one or other of the vulnerable stages of its life-history when it is most open to attack, and usually at a stage when it is incapable of flight. One of these vulnerable stages is the egg,

and ploughing and harrowing have been employed, partly to cause direct destruction of the eggs lying in the egg-pods, partly to expose these to unfavourable conditions. The method appears to give results in no way comparable to the cost.

Against the insect in the hopper stage many methods are employed. In America hopper catching machines and hopper dozers are employed. These consists of screens dragged along the ground and fitted with some device for retaining the hoppers which may be dried and fed to poultry. Clearly they are useless against large swarms covering large tracts. Burning by petrol jets has proved efficacious but requires a trained band of operators. Ditches have the disadvantage of cost and have largely been replaced by portable barriers. The use of these latter requires considerable skill and technical knowledge in judging the direction of migration; they must be erected at night across the probable path of migration to lead the swarm to a trap where it may be destroyed. This, too, is an expensive method both in cost of the portable barriers and of labour in erection.

Chemical Methods.—These embrace the use of chemical substances acting either as external or internal poisons. The former include mineral oils, soap, and kerosene-soap emulsion. Their main defect is cost. The latter are variously applied. Spraying arsenical compounds over the natural vegetation supplying the food of the locust has been effectively organized on a large scale both in Russia and South Africa but it has the grave drawback of cost and the method is giving place to poisoned baits. The bait system is under process of evolution but, essentially, the bait is a compound of three ingredients, carrier, poison and attractant. As carrier green vegetable matter, horse manure, bran, sawdust, chaff and cotton-seed meal have proved successful, and of these bran proved most effective followed by a mixture of bran and sawdust or bran and chaff (wheat or oat, not millet). The essential point of the carrier is ability to absorb and retain moisture. Poisons are practically limited to arsenical compounds and white arsenic has proved most successful. Preferably the poison should be insoluble, to be retained by the carrier under rain. The nature of the attractant is as yet hardly understood and it may be that moisture itself is an adequate attractant. Many substances, including molasses, have been tried but with little advantage. Too little is as yet known concerning the sensory reactions of the locust. The distribution of the bait again, is a matter requiring considerable skill associated with knowledge of the insects' habits.

Another recent method of attack is the dusting of dry poisons, particularly sodium arsenite; it has the advantage that the poison reaches places inaccessible for baits and it can be employed by aeroplanes. Dusting calcium cyanide, which liberates cyanogas, has recently been adopted in South America with success.

Biological Methods.—From time to time those biological methods which have been adopted with success in the control of other insects have been proposed for the control of the locust and among these have figured numerous parasites, birds, fungi (particularly *Empusa grylli*) and bacteria (*Coccobacillus acridiorum*), the latter having been tried in the Argentine. The difficulties in the way of the employment of such methods in the case of an insect of incidental appearance are obvious and attempts have been marked by no success though they have their possibilities against solitary grasshoppers.

THE BEARING OF THE PHASE THEORY

The methods just discussed are directed mainly against the insect in its swarming or gregarious phase, and they constitute attempts at destruction of the swarms as soon after, but after, their first appearance as possible. If the phase theory is of too recent a date to have permitted the evolution of an effective method of control up to the present, it has indicated a new direction in which control must be sought. The phase theory if it be correct to term that a theory which has received general recognition, lays down that certain species of *Acrididae* pass through alternating phases, each lasting an indeterminate number of generations, in one of which the insect is gregarious and mobile and, in the other, solitary and stationary. Fundamental to the subject of control, therefore, is a determination of the conditions which stimulate the transference from one phase to the other. The immediate stimulus was shown by Uvarov to be density of insect population and his conclusions have been confirmed by Faure working on the migratory locust of South Africa. Where the insects occur in sufficient numbers to give the necessary contact between individuals, a definite stimulus towards gregariousness is aroused which is accompanied by those morphological modifications in the successive instar (hopper) stages which lead to the intermediate forms or, if the stimulus is sufficiently intense, to the extreme gregarious form. Conversely, if the numbers are reduced and the necessary stimulus lacking, the solitary form will be developed.

But this new knowledge leads only part of the way, though a large part, to the evolution of a practical solution of the economic problem. The question that awaits solution lies deeper and is this: what are the conditions under which so large a number of individuals are hatched out that contact adequate to provide the stimulus is forthcoming? There is here no regularity of sequence, for invasions of migratory locusts are characteristically irregular. Faure offers a number of observations on the effect of the major climatic factors, light, heat, and moisture, but, important as these are, the observed effects offered no solution to the problem.

Fortunately there is another line along which progress towards the solution of the practical problem can be made while awaiting a definite answer to this difficult question. Over the wide stretch of country in which any one species occurs there will be varying sets of environmental conditions, one or more of which will prove more favourable to the insect. Here, amid the normal fluctuations which commonly occur between successive seasons, there will arise times when conditions are more than usually favourable and numbers sufficient to provide a stimulus and to arouse the gregarious instinct will survive. The habitat, thus, becomes zonal. Surrounding the area is an outer zone, *the range of invasion*, penetrated only by the migratory swarms and offering conditions unfavourable for permanent occupation. Being gregarious the insects tend to lay their eggs in close association and sufficient may survive to cause a persistence of the gregarious phase for a few generations; but eventually reversion to the solitary phase takes place and even this may disappear. Within lies an inner zone, *the permanent habitat*, in which the solitary phase is permanently established. Within this again, will lie foci, *the areas of incipient swarming*, where the conditions are exceptionally favourable. Here the balance is nicely adjusted and any favourable swing will lead

to development of the gregarious form. These are the danger points, the points of origin of the migratory swarms which cause so much havoc in their progress. The new method of control suggested by the phase theory requires, as a preliminary, the demarcation of these danger foci. Concentration on them offers the most promising line of attack for, if successful, the development of the migratory phase will be prevented. The problem is no easy one and not the least of the difficulties lies in the probability that many of the foci lie in inaccessible regions. Thus, in South Africa, three foci have been determined for the Brown locust; one round Middelburgh, Steynsburgh and De Aar, a second round Hope Town, Herbert and Jacobsdaal, and the third in Kenhard. But much of the permanent habitat lies in *terra incognita* in the *Kalahari* and there may be other foci in this region. The determination of foci is, however, but one stage towards the solution; there remains the question of how these foci are to be dealt with when located. It is not practicable to plough, drag, spray or bait large and indeterminate areas so far removed from the haunts of man though the potentialities of dusting from aeroplanes as well as of some form of biological control must not lightly be dismissed. A further possibility lies in a modification of the conditions so as to render them less favourable. There is here opened up an ecological problem of no mean order but one on which attention is now being concentrated. Thus the solution of the problem of the locust, a gregarious and migratory insect, is now being sought from an intensive study of a solitary and sedentary grasshopper. Once again scientific investigation has led to unexpected and surprising conclusions.

Though the discovery of the assistance of phases in the life history of the locust is of such recent date and much remains to be learned relative to the conditioning causes of the transfer from the solitary to the gregarious phase, considerable progress has already been made in certain cases both in the determination of a foci and of the favourable ecological conditions. A brief statement of these results, in as far as they concern those forms whose range impinges on sugar producing areas, will be of interest.

The Migratory locust is the most widely distributed of all species and its range includes practically all the old world south of latitude 55° to 60° as well as Northern Queensland and New Zealand. Foci, though most common along the belt stretching across the Danube area and southern Siberia, occur in tropical areas in West Africa, Central Africa, Malaya, Borneo and Queensland. Outside the Russian area little is known of the ecological conditions of the foci or even their exact location, but reed beds, tall grass or bamboo associated with raised drier areas for oviposition seem to be the main essentials.

Reference has already been made to the Brown locust. The main ecological feature so far determined appears to be the character of the soil.

The Desert locust is, perhaps, the most destructive of all but the range of its intense depredations is the area bordering the Sahara and extending through Arabia and Persia to India where migratory swarms do considerable damage. Little is known as to the foci or the ecological conditions of these.

The South American locust ranges from the Argentine through Brazil, Venezuela and Central America, while migratory swarms may penetrate the West Indian Islands. The foci are not located and knowledge of the ecological conditions is consequently nil.

There is obviously a vast field to be explored before the locust will be brought under control, but the lines of that exploration are now clearly defined. They are lines along which none but a Government controlled agency can well work, for the locust is no respecter of the artificial boundaries drawn by man. In many cases they ignore even international boundaries by which further complication is added in the organization of control measures. This conclusion, however, in no way diminishes the need for local effort when swarms appear. Swarm breeds swarm if the locality offers favourable breeding ground and the insect is left in peace to breed. Local effort, by one of the methods referred to above, can do much to reduce the number of generations of the migratory phase and to increase the number of years of freedom from attack.

REVIEW

FIRST ANNUAL REPORT ON CACAO RESEARCH, 1931

THE Cacao Research Scheme, which started its active life at the end of 1930 and which has recently issued its first annual report, has its headquarters at the Imperial College of Tropical Agriculture, Trinidad, B.W.I. This institution serves the dual purpose of a training ground for future Colonial Agricultural Officers and tropical farmers and of a link in the chain of long-range research stations that were envisaged by the Lovat Committee, and it is in the latter capacity that it houses the Cacao Research Scheme. The scheme is financed by contributions from cacao-producing colonies and from three large cocoa manufacturers of Great Britain, Messrs. Cadbury, Fry and Rowntree. It is established in the first place for five years, at the end of which period the position will be reviewed. It has at present a staff of three research officers—a geneticist and a physiologist who work under the general supervision of the Professor of Botany of the College, and a soil chemist whose work is directed by the Professor of Chemistry.

A. Botanical Section.—The aims of the botanical section are briefly recapitulated by Profeessor E. E. Cheesman who originally devised them. The work of the section is directed towards the collection of information necessary for the improvement of yield and quality in Empire cacao. Improvements may be brought about in actual planting material (the work of the geneticist) and also in the environment in which the tree lives (the work of the physiologist). The present cacao population consists of a heterogeneous collection of good, bad and indifferent individuals and the geneticist's object is to select and propagate the best. How is he to know the best when he sees it? It would be quite fallacious to take the number of pods per tree per annum as the sole criterion of yield; it would undoubtedly separate the good from the bad, but it would not distinguish accurately between the good and the better. Factors such as size of pod, number of beans per pod, proportion of beans to shell, and the relation of all these factors to the position of the pod on the tree must be considered in finding the best trees. It will be seen that the field of enquiry is large and it is therefore necessary, if results are to be achieved in a reasonable time, that the fewest number of observations consistent with accuracy shall be taken. It has been one of the major tasks of the geneticist during the year under review to determine this minimum number. Statistics of pod length and diameter, shell thickness and ratio of length to diameter taken from three blocks, each of 100 trees, in different places, and extending over seven months in time, indicate that variability between different trees is greater than that between pods on any one tree, and that measurement of a random sample of thirty pods is sufficient to characterise a tree. Seasonal variability is large, but estimates based on

samples taken at the time of maximum bearing (January in Trinidad) are very close to the mean for the whole crop; the variability takes the form of a reduction in all dimensions which is progressive with the course of the dry season, and is accompanied by a slight change in shape.

Similar statistics have been taken of bean number per pod and ovule number per ovary. The number of beans per pod is found to be markedly variable, but the number of ovules per ovary is remarkably constant. The discrepancy between the number of ovules in the ovary and the number which successfully mature into seeds is very great, and the loss is said to be sometimes as much as 50 per cent. It would be more correct to say that it may be as high as 100 per cent., for there is no evidence that the failure of flowers to produce fruits is always to be ascribed to ovule sterility. It is concluded that bean number is unreliable for the characterisation of individual trees, a conclusion that is fairly obvious when one considers the number of external factors that operate in the production of the bean.

It is not always clear how the analysis of variance tables are derived from the records, and in one case at least there is an arithmetical error (p. 11 Table of Shell Thickness; the average of pod No. 7. should be 17 mm. and not 18 mm. as stated). Further, the conclusion that one measurement per pod will give a sufficiently accurate estimate of diameter will depend on the class intervals adopted when pods are tabulated according to diameter; taking the analysis of variance figures given, the standard error of mean differences is about 0·77 per cent, making differences between means of 2·3 per cent. significant, whereas this percentage difference is exceeded in the measurements of any one pod.

Preliminary studies of fruitfulness suggest that flower abcission is controlled by an osmotic mechanism; if this is confirmed it will throw light on the failure to set fruit of flowers produced in May and June (at the end of the dry season) when the concentration of osmotically-active materials is high. There is no evidence that wilting of cherelles (young pods) is due to incomplete pollination, but there is a distinct suggestion of a correlation between the initial rate of growth of the pistil and the number of successful pollinations.

The vegetative propagation of cacao has received attention in the form of an enquiry into the rooting of cuttings of various kinds. Root cuttings were a failure: hardwood cuttings were not rooted, but the formation of callus was successfully induced: softwood cuttings, stools and layers were all rooted with sufficient success to justify further study. It has yet to be decided whether stems raised from cuttings will stool or layer as readily as the young seedling trees used in the present experiments, and the influence of season on the success of propagation is as yet unknown.

B. Chemical Section.—With a view to getting a general idea of the environmental factors affecting the growth of cacao, two plots were chosen on the past performance of the trees growing on them, and detailed analysis of soil and environmental data were made. The plots were in

different districts, on different soil types; both are planted in old cacao and are similarly treated. The good plot gave an average of 69 pods per tree in the first six months of 1931 and the bad plot 11 pods per tree during the same period. The soil in the bad plot was much the heavier in texture and drainage was poor; in dry weather the top six inches of soil were dried out and in heavy rain the water table was only fifteen inches below the surface; in the good plot, on the other hand, the average level of the water table during the wet season was two feet eleven inches, and there was never danger of wilting during dry weather. It is only natural that these obvious differences should be reflected in the crop.

The C/N ratio of the first six inches of soil is appreciably lower in the bad plot, and is in accordance with a generalization that good cacao soils have a higher ratio than bad ones. The bad plot is deficient in available phosphate, with which the good plot is amply supplied, but the available potash is not markedly different.

Humidity and evaporation at ground level during the wet season were similar on the two plots, but during the dry season there was a much higher evaporation in the bad plot. At the level of the tree tops conditions favoured a higher rate of evaporation during the dry season and a lower rate during the wet season. These phenomena are no doubt connected with the density of the canopies of the two plots. The work is being continued and extended.

The more general aspect of soil type in cacao-growing lands has been investigated by a survey of the Gran Couva district, in the Central range. Profile samples have been taken at 44 points in a district of 28 square miles and have been classified. General deductions are that productivity is related to the C/N content of the top six inches of soil, and may be connected with the available phosphate content of the soil. The survey will be extended to other regions, both in cacao and in jungle, and the indications already obtained will be more closely examined.—J. C. Haigh.

MEETINGS, CONFERENCES, ETC.

THE TEA RESEARCH INSTITUTE OF CEYLON

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held at St. Coombs Estate, Talawakelle, on Friday, the 14th April 1933, at 2.15 p.m.

Present.—Mr. R. G. Coombe (Chairman), the Acting Director of Agriculture (Dr. J. C. Hutson), Major J. W. Oldfield, C.M.G., M.C., O.B.E., Messrs. R. D. Morrison, I. L. Cameron, John Horsfall, Jas. Forbes (Jnr.), A. W. L. Turner (Secretary) and by invitation Mr. J. W. Ferguson, Dr. C. H. Gadd (Acting Director), Messrs. T. Eden, F. R. Tubbs and John A. Rogers (Superintendent).

Absent.—The Hon'ble the Financial Secretary, Col. T. G. Jayawardene, Messrs. B. M. Selwyn, G. K. Stewart, M.S.C., and D. H. Kotalawala, M.S.C.

1. Notice calling the Meeting was read.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 15th December 1932, were confirmed.

3. MEMBERS OF THE BOARD, T. R. I.

Announced that Mr. J. A. D. Finch Noyes and Major H. Scoble Nicholson, O.B.E., had resigned and the Ceylon Estates Proprietary Association had nominated Messrs. R. D. Morrison and I. L. Cameron to fill the vacancies.

Announced that Major Oldfield, C.M.G., M.C., O.B.E., was proceeding on furlough at the end of April and asked for leave of absence as from the 15th April. Leave of absence was granted and the Ceylon Estates Proprietary Association's nomination of Mr. D. T. Richards to act for Major Oldfield was approved.

4. FINANCE

The Statement of Accounts as at February 28th was passed without comment.

Audited Accounts.—Copies of these Accounts were sent to each Member of the Board under cover of Circular dated the 27th February 1933, and were adopted by the Meeting.

Auditors.—On the recommendation of the Finance Sub-Committee Messrs. Ford, Rhodes, Thornton & Co., were re-elected the Institute's Auditors.

Depreciation.—The Finance Sub-Committee's recommendation that Depreciation should be calculated in accordance with common practice and not on the prime cost basis was adopted.

Empire Marketing Board.—Announced that the Empire Marketing Board had paid the full grant of £1,000 sanctioned by them for the purchase of Experimental Machinery and a report had been sent to them with regard to the manner in which the Capital grant had been expended.

Nettle Grub Campaign.—Announced that it was no longer considered necessary to rent Blarneywatte Bungalow and the agreement had been terminated on the 31st March 1933.

In this connection the Acting Director suggested that the work of the Passara Station should be extended to include agricultural field experimentation and not be confined to Entomology, as at present Gonakelle Estate had promised, subject to the approval of the Proprietors to lend 10 acres, free of charge, for experimental plots. All Laboratory work could be carried out in the two Nissen huts erected last year. He added that if this suggestion were adopted the Institute would then have Up-country, Low-country and Uva Stations, i.e. St. Coombs, Galatura and Passara.

The proposal was agreed to.

Tea Restriction.—It was agreed that Mr. G. K. Stewart, M.S.C., should be asked to do his utmost to obtain exemption for St. Coombs and be given power to take any steps he might consider necessary to obtain this end.

Sale of Gas Plant.—The Board endorsed the Finance Sub-Committee's confirmation of the Chairman's action in allowing the sale of the Willet Petrol Gas Plant.

Sanitation.—On the recommendations of the Finance Sub-Committee an additional Rs. 200/- for the current year was sanctioned. This sum will enable the necessary works to be carried out and provide for efficient supervision of all sanitation work. The whole of the sanitary staff to be under the charge of the Estate Superintendent.

New Clearing Drains.—The Finance Sub-Committee's recommendation that an additional Rs. 194/- be allowed was agreed to.

Upkeep of Clearings.—The Finance Sub-Committee's recommendation for an additional grant of Rs. 390/- under this heading was agreed to.

Uprooting Bad Jât Tea in New Clearings.—The Finance Sub-Committee's recommendation for a grant of Rs. 760/- for this work was agreed to.

5. SENIOR SCIENTIFIC STAFF

(a) *Director—Dr. Roland V. Norris.* Announced that Dr. Norris proceeded on 8½ months' leave on the 8th February, and Dr. Gadd took up duties as Acting Director.

(b) *Biochemist—Dr. D. I. Evans.* Reported that the resignation tendered by this officer dating from the 30th June, 1933, had been accepted and his application for 11 weeks' vacation leave granted. Dr. Evans sailed on April 5th.

(c) *Entomologist—Mr. C. B. R. King.* The Chairman said that this officer had been very ill for some time and two doctors had given certificates to the effect that he definitely needed a holiday in England to recuperate his health.

Three months' privilege leave was granted.

6. JUNIOR STAFF OF THE T. R. I.

Vernacular Examinations.—It was agreed that members of the Junior Staff having to qualify themselves in colloquial Tamil should be tested in Tamil by the Estate Superintendent and Visiting Agent or another planter and in Sinhalese by the Small-Holdings officer or other Sinhalese speaking officer of the Institute or other person nominated by the Director.

7. ST. COOMBS ESTATE

(a) *Visiting Agent's Report, dated the 8th January 1933.*—The Chairman said that a copy of this Report had been sent to each Member of the Board.

The Report was accepted without comment.

(b) *Factory Fires.*—Announced that the Commercial Union Assurance Company's letter had been referred to in *The Tea Quarterly.*

(c) *Surplus Teas.*—The Chairman referred to a letter from Mr. B. A. Campbell which had been forwarded by "London".

The Acting Director said that he thought it highly improbable that a new use for tea would be discovered because tea would not compare favourably with an animal feeding cake in food value and because tea was not palatable to most animals. He suggested that increased consumption could be obtained by propaganda rather than by research into possible new uses.

The Board approved.

8. EXPERIMENTAL SUB-COMMITTEE

Announced that copies of the Minutes of the Meeting of the Experimental Sub-Committee held on the 14th January, and 24th February 1933, had been sent to all Members of the Board.

At the request of the Chairman, Mr. Eden briefly outlined an experiment on the handling of young tea which is to be carried out on the 1931 clearing, and reviewed the position regarding green manure plants on St. Coombs.

Mr. Tubbs spoke on the methods of layering and centering of tea bushes.

The Acting Director suggested that it would be better to revert to the pratice of using the small scale machinery for manufacturing experiments and then try out good results on the factory machinery.

This was agreed to and it was decided that the Acting Director should write a short memorandum on the subject of experiments in manufacture such as he had outlined, and forward it to the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association, and the Members of the Board.

9. CONFERENCE OF THE T. R. I.

Announced that the Third Conference of the Institute was held at St. Coombs Estate on the 27th and 28th January, 1933. A full report of the proceedings were published in *The Tea Quarterly*.

10. SECOND COLOMBO CONFERENCE OF TEA BUYERS, BROKERS, ETC.

Announced that a Conference of Tea Buyers, Brokers, etc., was held on the 3rd February. A copy of the summary of discussions at this Conference was sent to each member of the Board on the 6th April.

11. SMALL-HOLDERS

Col. T. G. Jayawardene, V.D., was duly elected a Member of the Small-Holders' Sub-Committee, vice Mr. C. H. Z. Fernando resigned.

The Acting Director said that he had recently inspected the work of the Small-Holdings Officer and was pleased with the results.

12. ANNUAL REPORT OF THE T. R. I.

Announced that a copy of the Secretary's portion of the Annual Report was sent to each member of the Board. The various suggestions made by members had been incorporated and a copy of the Report sent to Government.

The Meeting closed with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

DEPARTMENTAL NOTES

ANTHRACNOSE OF PLANTAINS

MALCOLM PARK, A.R.C.S.,
GOVERNMENT MYCOLOGIST

THE name anthracnose is given to a group of diseases caused by closely allied fungi, the main symptom of which is a severe spotting of the diseased leaf or fruit. Anthracnoses common in Ceylon are those of mango, which causes the familiar spotting of the fruits, of pomegranate and of beans. Anthracnose of plantains is best known on over-ripe fruits where it causes black spots on the skin; the spots enlarge and may eventually cause a soft rot of the edible part of the fruits. This form of the disease is not at present of economic importance in Ceylon, since it can be avoided by careful handling and by the use of fruits before they are over-ripe. It may, however, assume a different character if plantains are exported to other countries from Ceylon.

The form of the disease about which this note is written is, so far as can be gathered from available literature, not found in any countries other than India and Ceylon. The disease is commonest in wet weather and makes its appearance soon after the fruits have set. It is most common on the cooking variety known as the Ash Plantain (S. *Alukehel*) which appears to be considerably more susceptible to the disease than any of the varieties commonly grown in Ceylon.

SYMPTOMS OF THE DISEASE

As stated above, the disease makes its apearance soon after the fruits have set. Infection usually takes place from the distal end of the fruits or 'fingers', *i.e.* the end furthest from the axis, and it is probable that such infection starts through the flowers. The main axis of the bunch sometimes becomes infected and the disease may spread from thence into the immature fruits through the stalk end. The symptoms displayed by infected fruits are the same in both types of infection. The diseased fruit turns black from the point of attack and the whole fruit is involved in a short time. The diseased fruit finally shrivels and dries but remains attached to the central stalk. The whole bunch may be affected but more commonly only one or two 'hands' are involved. The illustration (Plate VI) shows the general appearance of a diseased bunch.

CAUSE OF THE DISEASE

The disease is caused by the fungus *Gloeosporium musarum* and massess of spores or seeds of the fungus can be seen on the small shrivelled fruits. The spore-masses appear as small-incrustations which are moist and bright pink when fresh, becoming a dull-light pink after some time. They contain countless minute spores each one of which is

Plate VI. Anthracnose of Plantains

capable, under favourable conditions, of causing a fresh infection. The spores are spread from such diseased fruits in wet weather by rain splashes and in dry weather by wind. The fungus is one which is normally a saprophyte, living on decaying vegetable matter, and it is only under favourable conditions of temperature and humidity that it becomes a parasite. It commonly lives as a saprophyte on dead plantain leaves and trash which can be found in all plantain gardens and it is obvious therefore that a complete eradication of the fungus would be impracticable.

CONTROL OF THE DISEASE

The disease, so far as is known, occurs so rarely as to be negligible on varieties other than the Ash Plantain. In gardens where the Ash Plantain is grown, the fruit bunches should be watched in wet weather for the appearance of the disease. All diseased fruits should be removed as soon as the disease is seen in order to prevent the disease from spreading into the healthy 'hands' of the bunch. It is also suggested that when all the 'hands' are open, the main fruit stalk should be cut off as far back as the last 'hand' in order not to leave that part of the fruit stalk which will subsequently die and on which the fungus may live as a saprophyte.

It has been shown in India that spraying of the young developing fruits at the beginning of the wet season and repeating the spraying once a month until the bunches are picked, will prevent the appearance of the disease. The disease in Ceylon does not appear to be sufficiently common to warrant spraying as a general rule but, if the susceptible variety, the Ash Plantain, were grown on a commercial scale, spraying would not only be practicable but well worth while. Any efficient copper spray would prove to be satisfactory and details of the preparation and method of application of a cheap and reliable spray may be obtained from any Agricultural Instructor or from the writer.

It has been stated above that the fungus is common on dead leaves and decaying plantain trash. It follows therefore that the cleaner the cultivation, the less common the fungus and subsequently the less the likelihood of the occurrence of the disease. The disease is least common on plantains grown in gardens where careful and clean cultivation is practised.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 MAY, 1933

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	24	2	21	1	2	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	11	...	...	10	...	1
	Piroplasmosis	...	...		...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	28	...	27	1	...	...
	Anthrax	3	...	...	3	...	...
	Rabies (Dogs)	17	2	...	...	...	17
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease (Sheep & Goats)	114	22	107	7	...	...
	Anthrax (Sheep & Goats)	69	3	...	69	...	...
Central	Rinderpest	65	...	11	52	...	2
	Foot-and-mouth disease	3	...	3	...	...	...
	Anthrax	10	...	...	10	...	...
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	50	...	50	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	1	...	...	...	...	1
Northern	Rinderpest	1082*	516	168	845	38	31
	Foot-and-mouth disease	4	..	4	...	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	52	...	51	1	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease	3	...	3	...	...	...
	Anthrax	...	...	..	...	...	...
	Pleuro-Pneumonia (Goats)	3	...	...	1	...	2
	Rabies (Dogs)	2	1	...	1	...	1
North-Central	Rinderpest	898	54	159	714	4	21
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	..
	Bovine Tuberculosis	2	...	...	...	..	2
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Haemorrhagic Septicaemia	3	...	...	3	...	...
	Rabies (Dogs)	...	...	...	...	...	...

* 443 cases occurred during April, 1933.

G. V. S. Office,
Colombo, 12th June, 1933.

M. CRAWFORD,
Govt. Veterinary Surgeon.

METEOROLOGICAL REPORT

MAY, 1933

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	85·7	− 1·1	75·9	− 1·3	79	88	8·2	20·89	28	+ 6·20
Puttalam -	86·6	− 0·9	76·4	− 2·1	78	91	7·3	11·07	25	+ 7·41
Mannar -	88·3	− 1·6	78·3	− 2·0	76	86	8·4	2·78	14	+ 0·67
Jaffna -	87·4	− 0·1	79·2	− 2·1	86	94	6·3	7·81	13	+ 5·98
Trincomalee -	87·6	− 3·3	77·0	− 1·2	72	86	7·0	3·49	11	+ 0·75
Batticaloa -	89·4	− 0·5	76·8	− 0·5	66	84	6·0	3·45	6	+ 1·62
Hambantota -	84·9	− 1·3	75·3	− 1·6	80	91	6·7	10·60	25	+ 7·27
Galle -	84·4	− 0·3	75·6	− 1·9	83	91	7·5	20·81	27	+ 9·31
Ratnapura -	87·1	− 0·9	73·7	− 0·9	83	95	8·2	33·95	28	+ 15·44
A'pura -	87·7	− 1·3	74·6	− 1·5	71	90	8·6	10·12	22	+ 6·55
Kurunegala -	87·7	− 0·8	74·6	− 1·1	76	93	8·9	24·52	26	+ 17·79
Kandy -	83·3	− 2·6	70·3	− 0·4	78	97	8·2	30·30	27	+ 24·45
Badulla -	81·9	− 3·0	66·8	+ 0·4	83	97	7·6	10·93	22	+ 6·26
Diyatalawa -	75·5	− 3·3	63·2	+ 1·4	76	87	8·4	14·26	22	+ 8·97
Hakgala -	68·6	− 4·3	57·1	− 0·8	88	94	7·5	27·81	28	+ 20·60
N'Eliya -	67·0	− 2·9	54·4	+ 1·2	84	94	8·8	34·81	29	+ 27·78

The rainfall of May was above its average almost everywhere in Ceylon, the only deficits reported being from a few stations in the Eastern Province. Excess of rain was particularly well marked on the western slopes of the hills, where several stations recorded more than 40 inches above their May normals. Padupola reported not only the largest total rainfall for the month, 72·18 inches, but also the greatest excess above average, over 48 inches. Other stations reporting totals of more than 60 inches were Kenilworth Estate, Watawala, Theydon Bois and Blackwater Estates.

At many stations on the lower western slopes of the hills the rainfall this May was substantially above the highest monthly total recorded for any previous May. The monthly total at Padupola, 72·18 inches, has only once been exceeded there in any month of the year, (October, 1913, 74·97 inches), during the 62 years over which observations have been continued at that station.

More than 170 reports of rainfalls of over 5 inches in a day were received, of which 35 were over 8 inches The largest daily fall reported was 11·85 inches at Padupola on the 21st-22nd. The great majority of these heavy falls occurred between the 21st and 25th, when unusually strong south-west monsoon conditions prevailed over Ceylon.

The weather during the first half of the month was of the intermonsoon type, with fairly heavy local afternoon or evening rains. About the 17th, however, a definite south-westerly gradient set in across the Island. Until the 21st this gave only moderately heavy rain, but for a week after that date, and particularly up to the 25th, the south-west of the Island experienced exceptionally heavy falls. Watawala, near the head of the Ginigathena Pass, reported over 46 inches of rain in these 7 days, of which over 35 inches fell in the first 4 days, 21st-25th.

As a result of the heavy rains in the Kelani Valley, there was considerable flooding in the river, a major flood, of practicaly 10 feet, being measured at Nagalagam Street. For several days there were also unusually high winds and stormy conditions at sea. About the 28th, weather conditions commenced to moderate again, though there was still appreciable rain, mainly in the south-west of the Island.

Temperatures, particularly during the day, were below normal, though not usually by large amounts. Humidity and cloud were both above average. Barometric pressure was above average, while wind was generally below average. Wind directions were, on the whole, south-westerly.

H. JAMESON,
Supdt., Observatory.